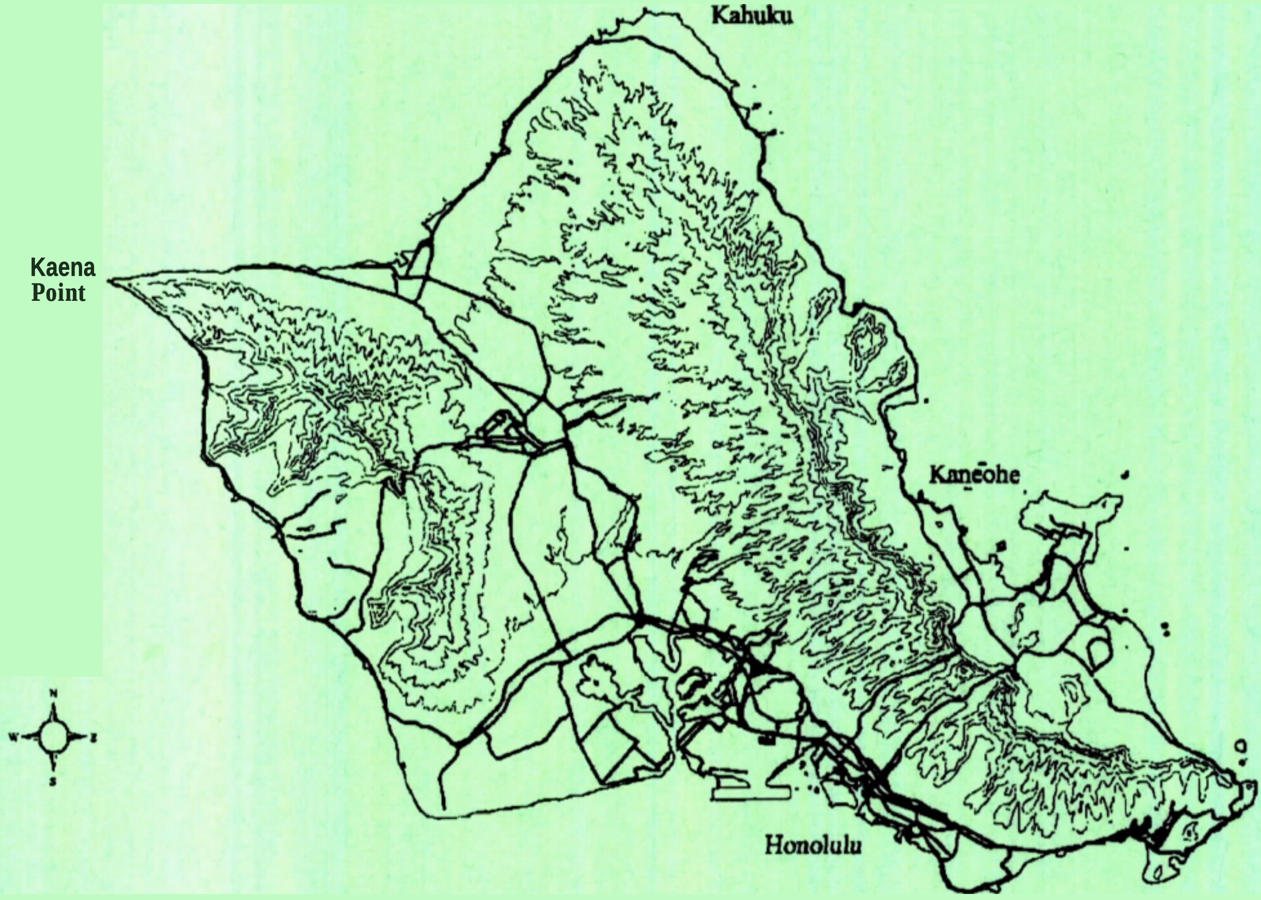
Recovery Plan for the Oahu Plants



RECOVERY PLAN FOR THE OAHU PLANTS

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DISCLAIMER PAGE

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for task implementation and/or time for achievement of recovery are only estimates and are subject to change. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature Citation: U.S. Fish and Wildlife Service. 1998. Recovery Plan for Oahu Plants. U.S. Fish and Wildlife Service, Portland, Oregon. 207 pp., plus appendices.

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EXECUTIVE SUMMARY

Current Species Status: The Recovery Plan for the Oahu Plants covers 66 plant taxa, all of which are listed as endangered. This Recovery Plan combines the Koolau Mountain Plant Cluster (USFWS 1996a) and Waianae Mountain Plant Cluster (USFWS 1995) Recovery Plans with newly listed species (USFWS 1996b) for which a Recovery Plan has never been completed. The numbers of known remaining populations and individuals are as follows:

TAXON	POPULATIONS	INDIVIDUALS
Abutilon sandwicense	14	< 300
Alsinidendron obovatum	4	12
Alsinidendron trinerve	3	108
Chamaesyce celastroides var. *kaenana*	10	545
Chamaesyce deppeana	1	<50
Chamaesyce herbstii	4	< 200
Chamaesyce kuwaleana	3	2,000
Chamaesyce rockii	11	200 – 400
Cyanea acuminata	15	< 100
Cyanea crispa	7	40
Cyanea grimesiana ssp. *obatae*	3	13
Cyanea humboldtiana	3	125 – 225
Cyanea koolauensis	22	< 80
Cyanea longiflora	3	200 – 220
Cyanea pinnatifida	1	1
Cyanea st.-johnii	6	40 – 50
Cyanea superba	1	5
Cyanea truncata	no known populations	0
Cyrtandra crenata	no known populations	0
Cyrtandra dentata	4	< 70
Cyrtandra polyantha	2	5
Cyrtandra subumbellata	3	< 50
Cyrtandra viridiflora	4	21
Delissea subcordata	18	< 80
Diellia falcata	22	5,540 – 6,540
Diellia unisora	4	700
Dubautia herbstobatae	4	525
Eragrostis fosbergii	4	6
Eugenia koolauensis	8	< 220
Gardenia mannii	28	70 – 100
Gouania meyenii	7	92

Gouania vitifolia	3	26
Hedyotis degeneri	3	32
Hedyotis parvula	4	220 – 235
Hesperomannia arborescens	15	< 100
Hesperomannia arbuscula	5	90
Labordia cyrtandrae	5	13
Lepidium arbuscula	10	< 900
Lipochaeta lobata var. *leptophylla*	3	142
Lipochaeta tenuifolia	9	2,000
Lobelia gaudichaudii ssp. *koolauensis*	4	< 280
Lobelia monostachya	1	8
Lobelia niihauensis	33	967 – 2,852
Lobelia oahuensis	11	110
Melicope lydgatei	3	< 45
Melicope saint-johnii	6	< 150
Myrsine juddii	3	500 – 3,000
Neraudia angulata	15	110
Nototrichium humile	15	1,500 – 1,600
Phlegmariurus nutans	3	4
Phyllostegia hirsuta	16	150 – 200
Phyllostegia kaalaensis	6	< 40
Phyllostegia mollis	5	120 – 140
Pritchardia kaalae	5	130
Sanicula mariversa	2	75
Schiedea kaalae	7	13
Schiedea kealiae	4	300 – 500
Silene perlmanii	no known populations	0
Stenogyne kanehoana	no known populations	0
Tetramolopium filiforme	5	1,550
Tetramolopium lepidotum ssp. *lepidotum*	3	44 – 63
Tetraplasandra gymnocarpa	17	< 200
Trematolobelia singularis	3	165
Urera kaalae	10	44
Viola chamissoniana ssp. *chamissoniana*	6	257
Viola oahuensis	8	< 180

Fifty-six of these taxa are endemic to the island of Oahu. The following taxa also have current populations outside of the island of Oahu: *Gouania meyenii* and *Lobelia niihauensis* on Kauai; *Hesperomannia arborescens* on Molokai and Maui; *Hesperomannia arbuscula* on West Maui; *Nototrichium humile* and *Phyllostegia mollis* on East Maui; and *Gouania vitifolia* on Hawaii. Historically, two of the taxa were known from Molokai (*Eugenia koolauensis* and *Phyllostegia mollis*), two from Lanai (*Hesperomannia arborescens* and *Tetramolopium lepidotum* ssp.

lepidotum), and one each from Kauai (*Phlegmariurus nutans*), West Maui (*Gouania vitifolia*), Niihau (*Lobelia niihauensis*), and Hawaii (*Gouania vitifolia*).

Habitat Requirements and Limiting Factors: The 66 taxa included in this plan grow in a variety of vegetation communities (lowland and mesic forests, shrublands, and volcanic cliffs) elevation zones (coastal to high cliff faces), and moisture regimes (dry and wet). These taxa and their habitats have been variously affected or are currently threatened by one or more of the following: trampling, predation, and habitat degradation by feral or domestic animals (goats, pigs, and cattle); competition for space, light, water, and nutrients by introduced vegetation; loss of pollinators; introduced bird species; erosion of substrate produced by human- or animal-caused disturbance; recreational and agricultural activities; habitat loss from fires; disease; and predation by rats, insects, slugs, snails. In addition, due to the small number of existing individuals and their very narrow distributions, these taxa are subject to an increased likelihood of extinction and/or reduced reproductive vigor from risk from random, naturally-occurring events.

Recovery Objectives: The ultimate objective is delisting of all taxa. Interim and downlisting objectives are provided to stabilize extremely rare taxa and downlist the taxa to threatened status. Recovery of the Oahu plants should be pursued by establishing management units that use available resources efficiently to conserve not only these taxa, but their habitats as well.

Recovery Criteria:
Interim Objectives

The interim objective is to stabilize all existing populations of the Oahu taxa. To be considered stable, each taxon must be managed to control threats (e.g., fenced) and be represented in an *ex situ* (at other than its original site, such as a nursery or arboretum) collection. In addition, a minimum total of 3 populations of each taxon should be documented on Oahu, and, if possible, at least one other island where they now occur or occurred historically. Each population must be naturally reproducing and increasing in number, with a minimum of 25 mature individuals per population for long-lived perennials (*Eugenia koolauensis, Hesperomannia arborescens, Hesperomannia arbuscula, Melicope lydgatei, Melicope saint-johnii, Pritchardia kaalae, Tetraplasandra gymnocarpa, and Urera kaalae*) and a minimum of 50 mature individuals per population for short-lived perennials (*Abutilon sandwicense*, *Alsinidendron obovatum*, *Alsinidendron trinerve*, *Chamaesyce celastroides* var. *kaenana*, *Chamaesyce deppeana, Chamaesyce herbstii, Chamaesyce kuwaleana*, *Chamaesyce rockii, Cyanea acuminata, Cyanea crispa, Cyanea grimesiana* ssp. *obatae*, *Cyanea humboldtiana, Cyanea koolauensis, Cyanea longiflora, Cyanea pinnatifida*, *Cyanea st.-johnii, Cyanea superba*, *Cyanea truncata, Cyrtandra crenata, Cyrtandra dentata, Cyrtandra* *polyantha, Cyrtandra subumbellata, Cyrtandra viridiflora, Delissea subcordata, Diellia falcata, Diellia unisora, Dubautia herbstobatae, Eragrostis fosbergii, Gardenia mannii, Gouania meyenii, Gouania vitifolia, Hedyotis degeneri, Hedyotis parvula, Labordia cyrtandrae, Lepidium arbuscula, Lipochaeta lobata* var. *leptophylla, Lipochaeta tenuifolia, Lobelia gaudichaudii* ssp. *koolauensis, Lobelia monostachya, Lobelia niihauensis, Lobelia oahuensis, Myrsine juddii, Neraudia angulata, Nototrichium humile, Phlegmariurus nutans, Phyllostegia hirsuta, Phyllostegia kaalaensis, Phyllostegia mollis, Sanicula mariversa, Schiedea kaalae, Schiedea kealiae, Silene perlmanii, Stenogyne kanehoana, Tetramolopium filiforme, Tetramolopium lepidotum* ssp. *lepidotum, Trematolobelia singularis, Viola chamissoniana* ssp. *chamissoniana*, and *Viola oahuensis*).

Downlisting Objectives

For downlisting, a total of five to seven populations of each taxon should be documented on Oahu and at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure, with a minimum of 100 mature individuals per population for long-lived perennials and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of 5 consecutive years before downlisting is considered.

Delisting Objectives

A total of 8 to 10 populations of each taxon should be documented on Oahu and at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of 5 consecutive years.

Actions Needed:

1. Protect habitat and control threats.
2. Expand existing wild populations.
3. Conduct essential research.
4. Develop and maintain monitoring plans.
5. Reestablish wild populations within historic range.
6. Validate and revise recovery criteria.

Total Estimated Cost of Recovery ($1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1998	415	0	0	0	0	0	415
1999	1162	150	865	165	0	0	342
2000	2122	150	865	165	40	0	3342
2001	2166	150	781	60	40	0	3197
2002	2136	150	781	60	40	0	3167
2003	1911	150	781	60	40	0	2942
2004	1897	0	781	60	40	0	2778
2005	1897	0	781	60	0	0	2738
2006	1897	0	781	60	0	0	2738
2007	1822	0	781	60	0	0	2663
2008	1822	0	781	60	0	0	2663
2009	1628	0	26	60	0	0	1714
2010	1628	0	26	60	0	0	1714
2011	1628	0	26	60	0	0	1714
2012	1628	0	26	60	0	0	1714
2013	1283	0	26	60	0	0	1369
2014	1283	0	26	60	0	120	1429
2015	1283	0	26	60	0	120	1429
2016	1283	0	26	60	0	160	1469
2017	1283	0	26	60	0	40	1409
2018	1283	0	26	60	0	40	1409
Total	33,457	750	8238	1410	200	300	44,355

Some costs are yet to be determined.

Date of Recovery: Downlisting to Threatened may be considered in 2018, if recovery criteria have been met.

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A. Brief Overview

The Recovery Plan for Oahu Plants covers 66 plant taxa, all of which are listed as endangered. This Recovery Plan combines two existing Recovery Plans (USFWS 1995; USFWS 1996a) with newly listed species for which a Recovery Plan has never been completed (USFWS 1996b). Much of this section was taken directly from the above referenced documents with some modifications.

This recovery plan covers the following 66 plant taxa:

Abutilon sandwicense (no common name [NCN]),
Alsinidendron obovatum (NCN),
Alsinidendron trinerve (NCN),
Chamaesyce celastroides var. *kaenana* (akoko),
Chamaesyce deppeana (akoko),
Chamaesyce herbstii (akoko),
Chamaesyce kuwaleana (akoko),
Chamaesyce rockii (akoko),
Cyanea acuminata (haha),
Cyanea crispa (NCN),
Cyanea grimesiana ssp. *obatae* (haha),
Cyanea humboldtiana (haha),
Cyanea koolauensis (haha),
Cyanea longiflora (haha),
Cyanea pinnatifida (haha),
Cyanea st.-johnii (haha),
Cyanea superba (haha),
Cyanea truncata (haha),
Cyrtandra crenata (haiwale),
Cyrtandra dentata (haiwale),
Cyrtandra polyantha (haiwale),
Cyrtandra subumbellata (haiwale),
Cyrtandra viridiflora (haiwale),
Delissea subcordata (NCN),
Diellia falcata (NCN),
Diellia unisora (NCN),
Dubautia herbstobatae (naenae),
Eragrostis fosbergii (NCN),
Eugenia koolauensis (nioi),
Gardenia mannii (nanu),
Gouania meyenii (NCN),
Gouania vitifolia (NCN),
Hedyotis degeneri (NCN),
Hedyotis parvula (NCN),
Hesperomannia arborescens (NCN),
Hesperomannia arbuscula (NCN),
Labordia cyrtandrae (kamakahala),
Lepidium arbuscula (anaunau),
Lipochaeta lobata var. *leptophylla* (nehe),
Lipochaeta tenuifolia (NCN),
Lobelia gaudichaudii ssp. *koolauensis* (NCN),
Lobelia monostachya (NCN),
Lobelia niihauensis (NCN),
Lobelia oahuensis (NCN),
Melicope lydgatei (alani),
Melicope saint-johnii (alani),
Myrsine juddii (kolea),
Neraudia angulata (NCN),
Nototrichium humile (kului),
Phlegmariurus nutans (wawaeiole),
Phyllostegia hirsuta (NCN),
Phyllostegia kaalaensis (NCN),
Phyllostegia mollis (NCN),

Pritchardia kaalae (loulu),
Sanicula mariversa (NCN),
Schiedea kaalae (NCN),
Schiedea kealiae (NCN),
Silene perlmanii (NCN),
Stenogyne kanehoana (NCN),
Tetramolopium filiforme (NCN),
Tetramolopium lepidotum ssp. *lepidotum* (NCN),
Tetraplasandra gymnocarpa (oheohe),
Trematolobelia singularis (NCN),
Urera kaalae (opuhe),
Viola chamissoniana ssp. *chamissoniana* (pamakani),
and *Viola oahuensis* (NCN).

Fifty-six of these taxa are endemic to the island of Oahu. The following taxa also have current populations outside of the island of Oahu: *Gouania meyenii* and *Lobelia niihauensis* on Kauai; *Hesperomannia arborescens* on Molokai and Maui; *Hesperomannia arbuscula* on West Maui; *Nototrichium humile* and *Phyllostegia mollis* on East Maui; and *Tetramolopium lepidotum* spp. *lepidotum* on Hawaii. Historically, two of the taxa were known from Molokai (*Eugenia koolauensis* and *Phyllostegia mollis*), two from Lanai (*Hesperomannia arborescens* and *Tetramolopium lepidotum* ssp. *lepidotum*), and one each from Kauai (*Phlegmariurus nutans*), West Maui (*Gouania vitifolia*), Niihau (*Lobelia niihauensis*), and Hawaii (*Gouania vitifolia*).

The 66 plant taxa and their habitats have been variously affected and are currently threatened by one or more of the following: habitat degradation and/or predation by feral or domestic animals (cattle, goats, and pigs); competition for space, light, water, and nutrients by naturalized, alien vegetation; habitat loss from fires; soil loss; predation by rats, insects, slugs, and snails; human recreational activities; and military training exercises. Because of the low numbers of individuals and their severely restricted distributions, populations of these taxa face an increased likelihood of extinction from randomly-occurring events.

Part I of this plan has been constructed in a species-by-species format, allowing the reader to find all information about a particular species in one section. The aim of this effort is to produce a comprehensive analysis of the threats to these taxa as well as a species-by-species analysis of the actions needed for stabilization and recovery. As ecosystem management units are identified, coordinated management of multiple populations and species will make recovery actions efficient.

The plant taxa addressed in this plan are all endemic to the eight "main Hawaiian Islands" (Figure 1), which include: Niihau, Kauai, Oahu, Maui, Molokai, Lanai, Kahoolawe, and Hawaii (also known as "the Big Island"). The Hawaiian Islands are located over 3,200 kilometers (2,000 miles) from the nearest continent. This isolation has allowed the few plants and animals that arrived here to evolve into many varied and highly endemic species. In many cases, these species lack defenses against threats such as mammalian predation and competition with aggressive, weedy plant species that are typical of mainland environments (Wagner *et al.* 1990).

B. General Description of Habitat

The island of Oahu was formed from the remnants of two large shield volcanoes, the younger Koolau volcano on the east and the older Waianae volcano to the west (Figure 2) (USFWS 1995, 1996a, 1996b). Their original shield volcano shape has been lost as a result of extensive erosion, and today these volcanoes are called mountains or ranges, and consist of long, narrow ridges. The Koolau Mountains were built by eruptions that took place primarily along a northwest-trending rift zone and formed a range now approximately 60 kilometers (37 miles) long (USFWS 1996a). Median annual rainfall for the Koolau Mountains varies from 100 to 700 centimeters (40 to 280 inches), most of which is received at higher elevations along the entire length of the windward (northeastern) side (USFWS 1996a).

The Waianae Mountains were built by eruptions that took place primarily along three rift zones. The two principal rift zones run in a northwestward and south-southeastward direction from the summit, and a lesser one runs to the northeast. The range is approximately 32 kilometers (20 miles) long. The caldera lies between the north side of Makaha Valley and the head of Nanakuli Valley (MacDonald *et al.* 1983). The Waianae Mountains are in the rain shadow of the parallel Koolau Mountains and receive much less rainfall, except for Mt. Kaala, the highest point on Oahu at 1,225 meters (4020 feet) (Wagner *et al.* 1990). The median annual rainfall for the Waianae Mountains varies from 51 to 19 centimeters (20 to 75 inches), with only the small summit area of Mt. Kaala receiving the highest amount.

Table 1 summarizes the habitat types in which the Oahu plants occur and some of the dominant plants of these habitats.

The vegetation communities of the Koolau Mountains, especially in the upper elevations to which many of the 66 plant taxa are restricted, are primarily lowland mesic and wet forests dominated by *Metrosideros polymorpha* (ohia) and/or other trees or ferns. Much of the Koolau Mountain Range is vegetated with alien plants. Most of the remaining native vegetation is restricted to steep valley headwalls and summit areas. The windswept ridges are very steep and are characterized by grasses, ferns, and low-growing, stunted shrubs (Gagné and Cuddihy 1990). Compared with the Koolau Mountains, the Waianae Mountains have a greater range of elevations, moisture regimes, and habitat types. As a result, the most biologically diverse region on the island of Oahu is the Waianae Mountains.

Table 2 lists the land owners of the current populations and historic habitat for the 66 plant taxa.

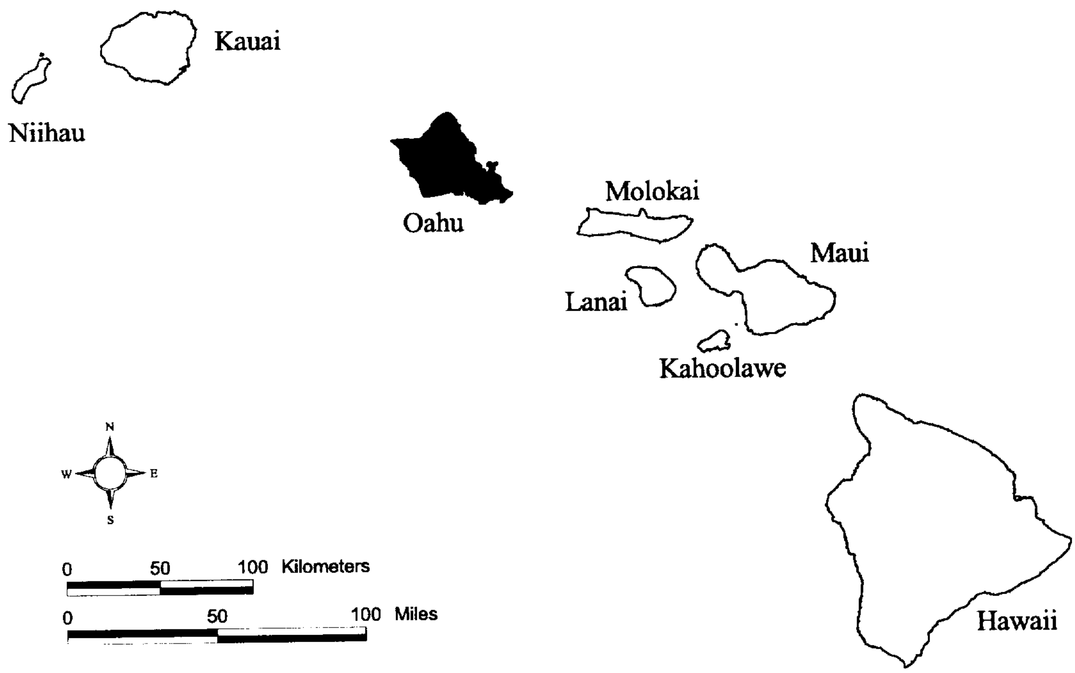

Figure 1. Map of the main Hawaiian Islands

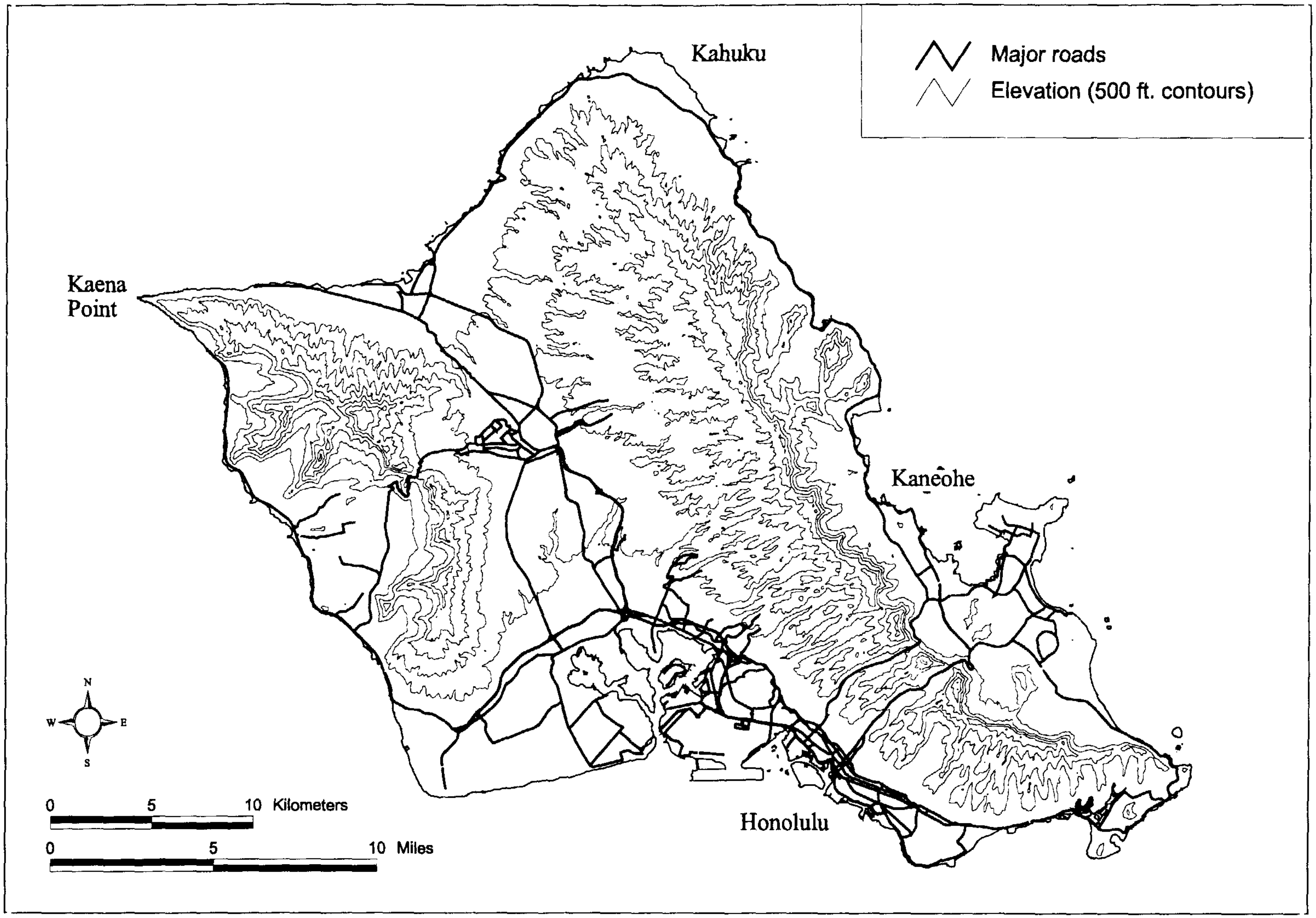

Figure 2. Map of the island of Oahu

Table 1. Summary of the Oahu plant taxa habitat types and associated plant species.

Habitat Type	Oahu Plants Recovery Plan Species	Some Associated Native Species	Some Associated Alien Species
<u>Coastal Dry Shrubland</u> elevation: 0–300 meters (0–990 feet) rainfall: <1,200 millimeters (47 inches) per year	*Chamaesyce celastroides* var. *kaeana*	*Psydrax odoratum* (alahee) *Eragrostis variabilis* (kawelu) *Gossypium tomentosum* (mao) *Jacquemontia ovalifolia* ssp. *sandwicensis* (pauohiiaka) *Bidens* sp. (kookoolau) *Lipochaeta* sp. (nehe) *Myoporum sandwicense* (naio) *Santalum freycinetianum* (iliahi) *Sida fallax* (ilima)	*Acacia farnesiana* (klu) *Cenchrus ciliaris* (buffelgrass) *Leucaena leucocephala* (koa haole) *Panicum maximum* (Guinea grass) *Prosopis pallida* (kiawe)

Table 1. Continued.

Habitat Type	Oahu Plants Recovery Plan Species	Some Associated Native Species	Some Associated Alien Species
Dry - Mesic Shrubland/Forest: 5–760 meters (17–2,508 feet) rainfall: <1,000–2,000 millimeters (39–78 inches) per year	*Abutilon sandwicense* *Alsinidendron obovatum* *Chamaesyce herbstii* *Chamaesyce kuwaleana* *Diellia falcata* *Diellia unisora* *Dubautia herbstobatae* *Gouania vitifolia* *Eugenia koolauensis* *Hedyotis degeneri* *Hedyotis parvula* *Hesperomannia arbuscula* *Lepidium arbuscula* *Lipochaeta lobata* var. *leptophylla* *Lipochaeta tenuifolia* *Lobelia monostachya* *Lobelia niihauensis* *Neraudia angulata* *Nototrichium humile* *Phyllostegia mollis* *Sanicula mariversa* *Schiedea kealiae* *Silene perlmanii* *Tetramolopium filiforme* *Tetramolopium lepidotum* ssp. *lepidotum* *Viola chamissoniana* ssp. *chamissoniana*	*Australia.* (ahinahina) *Bidens* spp. (kookoolau) *Bobea timonoides* (ahakea) *Capparis sandwichiana* (maiapilo) *Carex meyenii* (no common name [NCN]) *Diospyros sandwicensis* (lama) *Dodonaea viscosa* (aalii) *Eragrostis variabilis* (kawelu) *Erythrina sandwicensis* (wiliwili) *Lipochaeta* sp. (nehe) *Metrosideros polymorpha* (ohia) *Nestegis sandwicensis* (olopua) *Plectranthus parviflorus* (alaala wai nui) *Psydrax odoratum* (alahee) *Sida fallax* (ilima) *Sapindus oahuense* (aulu)	*Ageratina riparia (Hamakua pamakani)* *Cenchrus ciliaris* (buffelgrass) *Erigeron karvinskianus* (daisy fleabane) *Kalanchoe pinnata* (air plant) *Leucaena leucocephala* (koa haole) *Melinus minutiflora* (molasses grass) *Passiflora suberosa* (huehue haole) *Psidium cattleianum* (strawberry guava) *Schinus terebinthifolius* (Christmas berry) *Syzygium cumini* (Java plum)

Table 1. Continued

Habitat Type	Oahu Plants Recovery Plan Species	Some Associated Native Species	Some Associated Alien Species
Montane Mesic Forest	*Chamaesyce herbstii*	*Acacia koa* (koa)	*Ageratina riparia*
elevation:	*Cyanea acuminata*	*Alyxia oliviformis* (maile)	(Hamakua pamakani)
	Cyanea crispa	*Bidens* spp. (kookoolau)	*Aleurites moluccana* (kukui)
500–2,700 meters	*Cyanea grimesiana* ssp. *obatae*	*Bobea elatior* (ahakea lau nui)	*Clidemia hirta* (Koster's curse)
(1,600–8,800 feet)	*Cyanea longiflora*	*Cibotium* spp. (hapuu)	*Lantana camara* (lantana)
	Cyanea pinnatifida	*Claoxylon sandwicense* (poola)	*Melinus minutiflora*
rainfall:	*Cyanea superba*	*Coprosma foliosa* (pilo)	(molasses grass)
	Cyrtandra crenata	*Dicranopteris linearis* (uluhe)	*Myrica faya* (firetree)
1,200–2,500 millimeters	*Cyrtandra dentata*	*Diospyros hillebrandii* (lama)	*Passiflora suberosa*
(48–100 inches) per year	*Cyrtandra polyantha*	*Diospyros sandwicensis* (lama)	(huehue haole)
	Delissea subcordata	*Dodonaea viscosa* (aalii)	*Psidium cattleianum*
	Eragrostis fosbergii	*Dubautia* spp.(naenae)	(strawberry guava)
	Gardenia mannii	*Hibiscus arnottianus* (kokio keokeo)	*Rubus argutus*
	Gouania meyenii	*Labordia tinifolia* (kamakahala)	(prickly Florida blackberry)
	Gouania vitifolia	*Machaerina angustifolia* (uki)	*Schinus terebinthifolius*
	Labordia cyrtandra	*Metrosideros polymorpha* (ohia)	(Christmas berry)
	Lepidium arbuscula	*Myrsine* spp. (kolea)	*Toona ciliata*
	Melicope lydgatei	*Nestegis sandwicensis* (olopua)	(Australian red cedar)
	Melicope saint-johnii	*Pipturus albidus* (mamaki)	*Grevillea robusta* (silk oak)
	Phlegmariurus nutans	*Pisonia umbellifera* (papala kepau)	*Kalanchoe pinnata* (air plant)
	Phyllostegia hirsuta	*Pittosporum* spp. (hoawa)	
	Phyllostegia kaalaensis	*Pouteria sandwicensis* (alaa)	
	Pritchardia kaalae	*Psydrax odoratum* (alahee)	
	Schiedea kaalae	*Psychotria* spp. (kopiko)	
	Stenogyne kanehoana	*Rauvolfia sandwicensis* (hao)	
	Tetraplasandra gymnocarpa	*Touchardia latifolia* (olona)	
	Urera kaalae	*Urera glabra* (opuhe)	

Table 1. Continued.

Habitat Type	Oahu Plants Recovery Plan Species	Some Associated Native Species	Some Associated Alien Species
<u>Montane Wet Forest</u> elevation: 500–2,700 meters (1,600–8,800 feet) rainfall: greater than 2,500 millimeters (100 inches) per year	*Alsinidendron trinerve* *Chamaesyce deppeana* *Chamaesyce rockii* *Cyanea acuminata* *Cyanea crispa* *Cyanea koolauensis* *Cyanea longiflora* *Cyanea st.-johnii* *Cyrtandra crenata* *Cyrtandra subumbellata* *Cyrtandra viridiflora* *Gardenia mannii* *Labordia cyrtandrae* *Lobelia gaudichaudii* ssp. *koolauensis* *Lobelia oahuensis* *Melicope lydgatei* *Myrsine juddii* *Phlegmariurus nutans* *Phyllostegia hirsuta* *Tetraplasandra gymnocarpa* *Trematolobelia singularis* *Viola oahuensis*	*Antidesma platyphyllum* (hame) *Bidens* spp. (kookoolau) *Bobea elatior* (ahakea lau nui) *Broussaisia arguta* (kanawao) *Cheirodendron trigynum* (olapa) *Cibotium* spp. (hapuu) *Coprosma* spp. (pilo) *Cyrtandra* spp. (haiwale) *Dicranopteris linearis* (uluhe) *Diplopterygium pinnatum* (uluhe lau nui) *Dubautia laxa* (naenae pua melemele) *Freycinetia arborea* (ieie) *Hedyotis terminalis* (manono) *Hibiscus arnottianus* (kokio keokeo) *Ilex anomala* (kawau) *Labordia tinifolia* (kamakahala) *Machaerina* spp. (uki) *Melicope* spp. (alani) *Metrosideros polymorpha* (ohia) *Myrsine* spp. (kolea) *Pittosporum* spp. (hoawa) *Psychotria* spp. (kopiko) *Sadleria* spp. (amau) *Scaevola* spp. (naupaka kuahiwi) *Syzigium sandwicensis* (ohia ha) *Wikstroemia oahuensis* (akia)	*Ageratina adenophora* (Maui pamakani) *Aleurites moluccana* (kukui) *Axonopus fissifolius* (narrow leaved carpet grass) *Casuarina equisetifolia* (common ironwood) *Clidemia hirta* (Koster's curse) *Cordyline fruticosa* (ti) *Paspalum conjugatum* (Hilo grass) *Psidium cattleianum* (strawberry guava) *Rubus argutus* (prickly Florida blackberry) *Sacciolepis indica* (glenwood grass) *Schinus terebinthifolius* (Christmas berry)

Table 2. Stewardship for Current Populations/Historic Range of the Oahu Plants.

Species	Current Wild Populations and Individuals (No. Outplanted)	Current Populations[1]			Historic Range(H) and Current Populations by Island					Comments
		Fed.	State	Private	O	Ma	Mo	L	Ka	
Abutilon sandwicense	14, < 300	3	7	1	14	–	–	–	–	3 pops on City/County land
Alsinidendron obovatum	4, 12 (8)	1	3	–	4	–	–	–	–	
Alsinidendron trinerve	3, 108 (40 – 45)	3	–	–	3	–	–	–	–	
Chamaesyce celastroides var. *kaenana*	10, 545 (1)	1	9	–	10	–	–	–	–	
Chamaesyce deppeana	1, < 50	–	1	–	1	–	–	–	–	
Chamaesyce herbstii	4, < 200	–	3	1	4	–	–	–	–	
Chamaesyce kuwaleana	3, 2000	2	1	–	3	–	–	–	–	
Chamaesyce rockii	11, 200 – 400	1	–	10	11	–	–	–	–	
Cyanea acuminata	15, < 100	5	5	3	15	–	–	–	–	2 pops on City/County land
Cyanea crispa	7, 40	1	4	2	7	–	–	–	–	
Cyanea grimesiana ssp. *obatae*	3, 13	1	–	2	3	–	–	–	–	
Cyanea humboldtiana	3, 125 – 225	–	2	1	3	–	–	–	–	
Cyanea koolauensis	22, < 80	1	6	15	22	–	–	–	–	

Table 2. Continued

Species	Current Wild Populations and Individuals (No. Outplanted)	Current Populations [1]			Historic Range(H) and Current Populations by Island					Comments
		Fed.	State	Private	O	Ma	Mo	L	Ka	
Cyanea longiflora	3, 200 – 220	–	1	0	3	–	–	–	–	2 pops on City/County land
Cyanea pinnatifida	1, 1 (2)	–	–	1	1	–	–	–	–	
Cyanea st.-johnii	6, 40 – 50	–	2	4	6	–	–	–	–	
Cyanea superba	1, 5 (40)	1	–	–	1	–	–	–	–	
Cyanea truncata	0, 0	–	–	–	0	–	–	–	–	
Cyrtandra crenata	0, 0	–	–	–	0	–	–	–	–	
Cyrtandra dentata	4, < 70	1	2	1	4	–	–	–	–	
Cyrtandra polyantha	2, 5	–	1	1	2	–	–	–	–	
Cyrtandra subumbellata	3, < 50	1	1	1	3	–	–	–	–	
Cyrtandra viridiflora	4, 21	0	1	3	4	–	–	–	–	
Delissea subcordata	18, < 80 (3)	4	8	6	18	–	–	–	–	
Diellia falcata	22, 5,540 – 6,540	5	7	7	22	–	–	–	–	3 pops on City/County land
Diellia unisora	4, 700	–	2	2	4	–	–	–	–	
Dubautia herbstobatae	4, 525	1	2	–	4	–	–	–	–	1 pop on City/County land

Table 2. Continued

Species	Current Wild Populations and Individuals (No. Outplanted)	Current Populations [1]			Historic Range(H) and Current Populations by Island					Comments
		Fed.	State	Private	O	Ma	Mo	L	Ka	
Eragrostis fosbergii	4, 6	–	–	–	4	–	–	–	–	4 pops on City/County land
Eugenia koolauensis	8, < 220	0	5	3	8	–	H	–	–	
Gardenia mannii	28, 70 – 100	4	4	19	28	–	–	–	–	1 pop on City/County land
Gouania meyenii	7, 92	–	–	–	4	–	–	–	3	4 pops on City/County land
Gouania vitifolia	3, 26	–	3	–	1	H	–	–	–	2 pops on Hawaii
Hedyotis degeneri	3, 32	–	3	–	3	–	–	–	–	
Hedyotis parvula	4, 220 – 235	4	–	–	4	–	–	–	–	
Hesperomannia arborescens	15, < 100	2	7	6	13	1	1	H	–	
Hesperomannia arbuscula	5, 90	–	2	1	4	1	–	–	–	2 pops on City/County land
Labordia cyrtandrae	5, 13	4	1	–	5	–	–	–	–	
Lepidium arbuscula	10, < 900	4	6	–	10	–	–	–	–	
Lipochaeta lobata var. *leptophylla*	3, 142	3	–	–	3	–	–	–	–	

Table 2. Continued

Species	Current Wild Populations and Individuals (No. Outplanted)	Current Populations [1]			Historic Range(H) and Current Populations by Island					Comments
		Fed.	State	Private	O	Ma	Mo	L	Ka	
Lipochaeta tenuifolia	9, 2,000	3	3	–	9	–	–	–	–	3 pops on City/County land
Lobelia gaudichaudii ssp. *koolauensis*	4, < 280	1	–	2	3	–	–	–	–	
Lobelia monostachya	1, 8	–	1	–	1	–	–	–	–	
Lobelia niihauensis	33, 967 – 2,852	9	16	2	19	–	–	–	14	6 pops on City/County land Historically from Niihau
Lobelia oahuensis	11, 110	2	3	4	11	–	–	–	–	2 pops on City/County land
Melicope lydgatei	3, < 45	–	2	1	3	–	–	–	–	
Melicope saint–johnii	6, < 150	1	3	2	6	–	–	–	–	
Myrsine juddii	3, 500 – 3000	–	–	3	3	–	–	–	–	
Neraudia angulata	15, 110	9	1	3	16	–	–	–	–	3 pops on City/County land
Nototrichium humile	15, 1,500 – 1,600 (1)	4	7	1	14	1	–	–	–	3 pops on City/County land
Phlegmariurus nutans	3, 4	–	3	–	3	–	–	–	H	
Phyllostegia hirsuta	16, 150 – 200	4	3	7	16	–	–	–	–	2 pops on City/County land
Phyllostegia kaalaensis	6, < 40	–	2	3	6	–	–	–	–	1 pop on City/County land
Phyllostegia mollis	5, 120 – 140	2	1	2	4	1	H	–	–	

Table 2. Continued

Species	Current Wild Populations and Individuals (No. Outplanted)	Current Populations [1]			Historic Range(H) and Current Populations by Island					Comments
		Fed.	State	Private	O	Ma	Mo	L	Ka	
Pritchardia kaalae	5, 130	1	3	–	5	–	–	–	–	1 pop on City/County land
Sanicula mariversa	2, 75	1	1	–	2	–	–	–	–	
Schiedea kaalae	7, 13	–	3	4	7	–	–	–	–	
Schiedea kealiae	4, 300 – 500	1	2	1	4	–	–	–	–	
Silene perlmanii	0, 0	–	–	–	0	–	–	–	–	
Stenogyne kanehoana	0, 0	–	–	–	0	–	–	–	–	
Tetramolopium filiforme	5, 1, 550	3	1	–	5	–	–	–	–	1 pop on City/County land
Tetramolopium lepidotum ssp. *lepidotum*	3, 44 – 63 (2)	1	1	1	3	–	–	H	–	
Tetraplasandra gymnocarpa	17, < 200	2	6	8	16	–	–	–	–	1 pop on City/County land
Trematolobelia singularis	3, 165	1	1	1	3	–	–	–	–	
Urera kaalae	10, 44 (1)	1	1	7	10	–	–	–	–	1 pop on City/County land
Viola chamissoniana ssp. *chamissoniana*	6, 257	5	–	–	6	–	–	–	–	1 pop on City/County land
Viola oahuensis	8, < 180	2	–	6	8	–	–	–	–	

[1] Some populations occur on boundaries of jurisdiction.

C. Overall Reasons for Decline and Current Threats

The native vegetation of the Koolau and Waianae Mountains and adjacent areas has undergone extreme alterations because of past and present land management practices, including deliberate and accidental introductions of alien plants and animals, agricultural development, military use, and recreational use (Cuddihy and Stone 1990; Wagner *et al.* 1985). At the present time, the greatest threats to the 66 plant taxa in this recovery plan are habitat degradation by feral animals and competition with alien plants. Other significant threats include introduced rats, invertebrates and pathogens, fire, and loss of soil. Threats specific to each taxon are detailed in the species accounts and summarized in Table 3.

Feral Ungulates

Fifty-nine of the 66 taxa included in this plan are variously threatened by feral animals (Table 3). Animals such as pigs, goats, and cattle were introduced by the early Hawaiians (pigs) or more recently by European settlers (goats and cattle) for food and/or commercial ranching activities. Over the 200 years following their introduction, their numbers increased and the adverse effects of feral ungulates on native vegetation have become increasingly apparent. Beyond the direct effect of trampling and grazing native plants, feral ungulates have contributed significantly to dispersal of introduced plant species and to the heavy erosion still taking place on most of the main Hawaiian Islands (Cuddihy and Stone 1990).

Pigs (*Sus scrofa*), which were originally native to Europe, northern Africa, Asia Minor, and Asia, were introduced to Hawaii by the Polynesians. European pigs, introduced to Hawaii by Captain James Cook in 1778, escaped domestication and invaded the wet and mesic forests and grasslands of the islands of Kauai, Oahu, Molokai, Maui, and Hawaii. The pigs introduced by the Polynesians were apparently smaller and less destructive to native plants than the European pigs. In addition, it appears that Polynesian pigs were maintained in domestication and were not allowed to establish feral populations. Feral pigs have been in the Koolau and Waianae Mountains for about 150 years. They are major modifiers of wet forest habitats (Stone 1985). While foraging, pigs root and trample the forest floor, encouraging the establishment of alien plants in the newly disturbed soil. Pigs also disseminate alien plant seeds through their feces and on their bodies, accelerating the spread of alien plants through native forest (Cuddihy and Stone 1990; Stone 1985). Pigs are a major vector in the spread of habitat-altering weeds such as *Psidium cattleianum* (strawberry guava) and *Schinus terebinthifolius* (Christmas berry), and pigs enhance populations of *Rubus* *argutus* (prickly Florida blackberry), which threatens several of this plan's taxa (Cuddihy and Stone 1990; Smith 1985; Stone 1985). Feral pigs also feed on the starchy interiors of tree ferns (*Cibotium* spp.) and other succulent-stemmed plants.

The last known population of 3 individuals of *Cyanea truncata* in Hidden Valley was destroyed in recent years by feral pigs (USFWS 1996a). The continued impact of pigs poses an immediate and severe threat to any plants of *Cyanea truncata* that may remain (USFWS 1996a). Habitat degradation and predation of *Cyanea crispa* by pigs have been observed at the Hidden Valley population (USFWS 1996a). Feral pigs are known to frequent regions of the Koolau Mountains and threaten to destroy the habitat of 54 of the 66 Oahu plant taxa (USFWS 1995, 1996a, 1996b). The only population of *Hesperomannia arborescens* on Maui is threatened by pigs as well (USFWS 1996a).

Present throughout the Koolau and Waianae Mountains, feral pigs pose a significant threat to the native flora (USFWS 1995). For example, digging was noted in the wet summit forests within Honouliuli in the Waianae Mountains to which *Cyanea pinnatifida* is restricted (USFWS 1995). Fencing in Pahole Gulch in the northwestern Waianae Mountains has prevented a population of pigs from threatening at least two of the plant species in this recovery plan, *Alsinidendron trinerve* and *Schiedea kaalae* (Nagata 1980; Talbert Takahama, Department of Land and Natural Resources (DLNR), pers. comm. 1997).

Goats (*Capra hircus*) have become established on the islands of Hawaii, Kauai, Maui, Oahu, and Molokai (Cuddihy and Stone 1990, van Riper and van Riper 1982). Goats are managed in Hawaii as a game animal, but they can forage in extremely rugged terrain and populate inaccessible areas where hunting has little effect on their numbers (Culliney 1988). Feral goats eat native vegetation, trample roots and seedlings, cause erosion, and promote the invasion of alien plants. On Molokai, goats degrade dry forests at low elevations and are expanding their range (Cuddihy and Stone 1990; Joel Lau, The Nature Conservancy of Hawaii (TNCH), pers. comm. 1997). Goats browse on introduced and native plants, especially in dry, open ecosystems similar to that found between Wailau and Waiehu on the island of Molokai. In 1989, it was observed that numerous goats occupied the Wailau-Waiehu area and threatened the survival of the only population of *Hesperomannia arborescens* on the island (USFWS 1996a). Twenty-one species of the Oahu plant cluster are affected by goats (USFWS 1995, 1996a, 1996b). The current feral goat population on Oahu is in the Waianae Mountains because of the goat trade in the early 1820s, which allowed goats to proliferate without being confined by fences. The resultant damage by goats to the native flora has permanently altered Oahu's native ecosystems (Cuddihy and Stone 1990; Culliney 1988; Tomich 1986).

Cattle (*Bos taurus*) were once abundant on Oahu. Because of past restrictions on hunting, widespread ranching, and ineffective confinement of the animals, cattle populations boomed and spread to many parts of the island (Culliney 1988). The impact of cattle on native vegetation is similar to that described for goats (Cuddihy and Stone 1990, Scott *et al.* 1986, Tomich 1986). It was not until local land managers recognized the extent of the destruction of native vegetation by these animals that their numbers were controlled. However, by then much of the plant cover on cattle-grazing land on Oahu and other islands was already degraded. Such areas remained grassland for many years following the removal of cattle (Culliney 1988). Species such as *Abutilon sandwicense*, *Diellia falcata*, and *Nototrichium humile* have been detrimentally affected by the activities of cattle (USFWS 1995). Cattle that once roamed through the Koolau Mountains probably contributed to reducing the ranges of many native plants, including at least some of the 66 Oahu plant taxa. Cattle currently threaten three, or possibly four, of the 66 Oahu plant taxa.

Rats

Two rat species, the black rat (*Rattus rattus*) and the Polynesian rat (*Rattus exulans*), and to a lesser extent other introduced rodents, such as mice (*Mus* sp.), occur on all the main Hawaiian Islands around human habitations, in cultivated fields, and in dry to wet forests. Rats are known to eat the fruit and strip the bark of some native plants, particularly fruits of the native palms (*Pritchardia*) and plants in the bellflower (Campanulaceae) and African violet (Gesneriaceae) families with fleshy stems and fruits (Cuddihy and Stone 1990; Tomich 1986; Wagner *et al.* 1985). Many native Hawaiian plants produce their fruit over an extended period, producing a prolonged food supply which supports rodent populations. Rat predation on fruit threatens the largest population of *Pritchardia kaalae*, as indicated by the lack of reproduction and seedlings (Hawaii Heritage Program [HHP] 1997). Rats are suspected predators of 24 of the 66 Oahu plant taxa (USFWS 1995, 1996a, 1996b; Bill Garnett, Division of Forestry and Wildlife (DOFAW), pers. comm. 1997).

Alien Plants

Sixty-five of the 66 plant taxa are threatened by competition with one or more alien plant taxa (see Table 3). Alien plants compete with natives for space, light, water, and nutrients (Cuddihy and Stone 1990). The most significant aliens appear to be *Schinus terebinthifolius* (Christmas berry), *Psidium cattleianum* (strawberry guava), *Melinus minutiflora* (molasses grass), *Clidemia hirta* (Koster's curse), *Lantana camara* (lantana), *Leucaena leucocephala* (koa haole), *Rubus argutus* (prickly Florida blackberry), *Grevillea* *robusta* (silk oak), *Erigeron karvinskianus* (daisy fleabane), *Myrica faya* (firetree), *Paspalum conjugatum* (Hilo grass), *Casuarina equisetifolia* (common ironwood), *Passiflora suberosa* (huehue haole), *Ageratina adenophora* (Maui pamakani), *Ageratina riparia* (Hamakua pamakani), *Kalanchoe pinnata* (air plant), *Tibouchina herbacea* (a relative of Koster's curse), and *Ardisia elliptica,* (shoebutton ardisia). (USFWS 1995, 1996a, 1996b). A number of other alien plant taxa also significantly threaten populations of the plants in this plan.

After escaping from cultivation, **Christmas berry** became naturalized on most of the main Hawaiian Islands (Wagner *et al.* 1990) and is a pervasive threat in the Koolau and Waianae Mountains. This fast-growing tree, distributed mainly by feral pigs and fruit-eating birds, is able to form dense thickets that displace other plants and threatens the habitat of 38 of the 66 plant taxa (Cuddihy and Stone 1990; Smith 1985; Stone 1985; USFWS 1995, 1996a, 1996b); it may also release a chemical that inhibits the growth of other species (Smith 1985).

In Hawaii, three insects have been released by the Hawaii Department of Agriculture (HDOA) to control the non-native Christmas berry: *Bruchus atronotatus*, a beetle, was released in 1932, and *Crasimorpha infuscata* and *Episimus utilis,* both moths, were released in 1954. In addition, a thrip and a sawfly have been introduced to control this non-native tree in dry forests of Florida (Biocontrol of Forest Pests Steering Committee, *in litt.* 1997). However, success has been limited in all cases (M. Isherwood, HDOA, pers. comm. 1998). Currently, researchers are searching in its native Brazil for additional potential biological control agents for Christmas berry.

Strawberry guava, a tree native to tropical America, has become widely naturalized on all the main islands of Hawaii. Found in mesic and wet forests in the Koolau Mountains, strawberry guava develops into dense stands in which few other plants can grow, displacing natural vegetation. Strawberry guava is eaten by pigs and fruit-eating birds, which disperse the plant's seeds through the forest (Smith 1985; Wagner *et al.* 1985). Thirty-five of the 66 plant taxa are seriously threatened by this pervasive weed (USFWS 1995, 1996a, 1996b). To date, no biocontrol agents have been released against strawberry guava in Hawaii, though two species of insects are in quarantine and are currently undergoing host-screening (C. W. Smith, Cooperative Park Studies unit (CPSU), in *litt.* 1998).

Molasses grass, a perennial grass brought to Hawaii for cattle fodder, is now naturalized in dry to mesic, disturbed areas on most of the main Hawaiian Islands. The mats it forms smother other plants and fuel more intense fires than would normally affect an area (Cuddihy and Stone 1990; O'Connor 1990; Smith 1985). Molasses grass threatens 22 of the

66 plant taxa (USFWS 1995, 1996b). This plant has never been targeted for biological control (M. Isherwood, pers. comm. 1998).

Koster's curse, a noxious shrub first cultivated in Wahiawa on Oahu, spread to the Koolau Mountains before 1941 where it is now rapidly displacing native vegetation (Wagner *et al.* 1985). Koster's curse spread to the Waianae Mountains around 1970 and is now widespread throughout the southern half of that mountain range (Cuddihy and Stone 1990, Smith 1985, Wagner *et al.* 1985). This pest forms a dense understory, shading out other plants and hindering plant regeneration, and is considered the major alien plant threat in the Koolau Mountains (Smith 1989; USFWS 1996a). At present, Koster's curse threatens 33 of the 66 plant taxa (USFWS 1995, 1996a, 1996b).

Perhaps the most promising biological control agent against Koster's curse is the *Colleotrichum* fungus *Gloeosporioides* f. sp. *clidemiae* which is being released by DOFAW in conjunction with Dr. Eduardo Trujillo, a plant pathologist at the University of Hawaii. This fungus was first released in 1986 on Aiea Loop Trail, and has been subsequently released on all islands. Although there is no quantitative data available, it has an observable negative impact on Koster's curse.

Other biological control agents released by the HDOA include *Antiblemma acclinalis.* This noctuid moth from Trinidad and Tobago was released in 1995 and is currently established in the vicinity of the Aiea Loop Trail, Palolo Valley, and possibly Kalihi Valley. Further releases are planned on Army-managed land on Oahu. This moth was released on Kauai but did not become established. Another biological control agent, *Lius poseidon* (buprestid beetle), was initially released on Oahu, Maui, Kauai, and Hawaii in 1988. This beetle is currently established near the Aiea Loop Trail, and some leaf feeding has been observed, but damage is not significant. The fruit and flower-feeding insect, *Mompha trithalama,* was released in 1995-1996 but only a few recoveries were made in the Makiki area. *Carposina bullata* was introduced in 1985 and 1986, but it proved to be difficult to rear in captivity. The pyralid moth, *Ategumia matutinalis*, introduced in 1969 from Trinidad, is well established on Oahu, but damage to *Clidemia* foliage is insignificant (M. Isherwood, pers. comm. 1998). *Liothrips urichi*, introduced from Fiji in 1953, is well established and doing an excellent job in open areas, but has not been effective in the forest understory. This insect is considered to be a successful biological control agent because it feeds on terminal growth (M. Isherwood, pers. comm. 1998).

Lantana, native to tropical America, is an aggressive, thicket-forming shrub that produces chemicals that inhibit the growth of other plant species. Lantana is now found on all the main Hawaiian Islands in mesic forests, dry shrublands, and other dry, disturbed habitats (Smith 1985, Wagner *et al.* 1990). Lantana poses an immediate threat to the following five Oahu plant taxa: *Delissea subcordata, Eugenia koolauensis, Lepidium arbuscula, Melicope saint-johnii*, and *Phyllostegia hirsuta* (USFWS 1995, 1996a, 1996b).

Twenty-six insects have been introduced by HDOA from 1902 though 1951 for the biological control of lantana. Fifteen of these insects became established on one or more islands. Although lantana infestations are still prevalent in some localities on each island, they are not as significant as they were prior to the introduction of the biocontrol agents (M. Isherwood, pers. comm. 1998). A fungus, *Septoria lantana*, was released and established on Kauai in 1997 by DOFAW in cooperation with Dr. Trujillo of the University of Hawaii. It is too early to determine its impact (M. Isherwood, pers. comm. 1998).

Koa haole, a naturalized shrub, is sometimes the dominant plant in low elevation, dry, disturbed areas on all of the main Hawaiian Islands. Koa haole is an aggressive competitor that fixes nitrogen. It is a major threat to the following nine Oahu plant taxa: *Chamaesyce celastroides* var. *kaenana, Chamaesyce kuwaleana, Dubautia herbstobatae, Lipochaeta lobata* var. *leptophylla, Lipochaeta tenuifolia, Lobelia niihauensis, Nototrichium humile, Schiedea kealiae,* and *Tetramolopium filiforme* (Geesink *et al.* 1990, USFWS 1996a, 1996b). This species has never been targeted for biological control (M. Isherwood, pers. comm. 1998).

Prickly Florida blackberry was introduced to the Hawaiian Islands in the late 1800's from the continental U.S. (Haselwood and Motter 1983). The fruits are easily spread by birds to open areas such as disturbed mesic or wet forests, where the species forms dense, impenetrable thickets (Smith 1985). In the Waianae Mountains, populations of seven of the plant taxa are threatened by this noxious weed: *Alsinidendron trinerve, Cyanea acuminata, Cyanea longiflora, Gardenia mannii, Hesperomannia arbuscula, Labordia cyrtandrae, Phyllostegia hirsuta*, and *Pritchardia kaalae* (USFWS 1995, 1996b).

The Hawaii Department of Agriculture has released five insect biological control agents for prickly Florida blackberry. The blackberry skeletonizer, *Schreckensteinia festaliella*, was introduced from California in 1963. This heliodinid moth is established on Hawaii, Maui, and Kauai. After recent releases on Oahu's Mt. Kaala, it is now established at that site. Although feeding damage to terminal shoots is very noticeable in some localities, prickly Florida blackberry continues to outgrow the damage because soil moisture is always adequate in the habitat where it grows. A tortrioid moth, *Croesia zimmermani,* was introduced from Mexico in 1963. This species is established on Hawaii, Maui, and Kauai. Typically, it is a leaf-eater and has caused extensive damage to terminal shoots. However, as with the blackberry skeletonizer, the vigorous growth of the blackberry overcomes foliar damage. An aegerid moth, *Bembecia marginata*, was introduced from Oregon in 1963, but failed to become established. The blackberry sawfly, *Priophorus morio*, was introduced from Oregon in 1966. This tenthredinid is established on Kauai and Oahu (Mt. Kaala), but population densities are very low and damage to blackberry is negligible. A chrysomelid beetle, *Chlamisus gibbosa*, was introduced from Missouri in 1967 and 1968, but never became established (M. Isherwood, pers. comm. 1998).

Silk oak, native to Queensland and New South Wales, Australia, was planted extensively in Hawaii for timber and is now naturalized on most of the main islands (Smith 1985, Wagner *et al.* 1990). Silk oak negatively affects populations of four of the plant taxa that grow exclusively in the Waianae Mountains: *Chamaesyce herbstii, Eragrostis fosbergii, Lepidium arbuscula*, and *Melicope saint-johnii* (USFWS 1996b).

This species has not been targeted for biological control (M. Isherwood, pers. comm. 1998).

Daisy fleabane is another low-growing alien species that smothers native plants, particularly on cliffs, and is found on most of the Hawaiian Islands. This species threatens the following seven Oahu plant taxa: *Dubautia herbstobatae, Hedyotis parvula, Lobelia niihauensis, Tetramolopium filiforme*, *Tetramolopium lepidotum* ssp. *lepidotum*, and *Viola chamissoniana* ssp. *chamissoniana* (USFWS 1995).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998).

Firetree, native to the Azores, Madeira, and the Canary Islands, was introduced to Hawaii before 1900 for wine-making and firewood, or as an ornamental. Firetree was planted in forest reserves in the 1920's. By the mid-1980's, firetree had infested over 34,000 hectares (84,000 acres) throughout the State, with the largest infestations on the island of Hawaii. It is now considered a noxious weed (Cuddihy and Stone 1990). Firetree can form a dense stand with no ground cover beneath the canopy. This lack of ground cover may be due to dense shading or to chemicals released by firetree that prevent other species from growing. Firetree also fixes nitrogen and increases nitrogen levels in Hawaii's typically nitrogen-poor volcanic soils. This may encourage the invasion of alien plants that would not otherwise grow as well as native species in Hawaii's low-nitrogen soils (Cuddihy and Stone 1990). Firetree threatens the following six Oahu plant taxa: *Melicope saint-johnii, Schiedea kaalae, Silene perlmanii, Tetramolopium lepidotum* ssp. *lepidotum, Urera kaalae* and one of the largest populations of *Lepidium arbuscula* (USFWS 1995, 1996b).

On Oahu, no biological control agents have been released against firetree. A fungus, *Septoria myricae*, was recently released on the Big Island. There is, as yet, no evidence of effect. The U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is currently considering the release of the leaf-mining moth, *Phyllonorycter myricae*, as a biocontrol agent for firetree. A leaf roller has been released on the Big Island but has had little impact on fire tree. It has also been released on Kauai, but the results are not yet available (M. Isherwood, pers. comm. 1998).

Hilo grass is one of several perennial grasses purposely introduced for cattle fodder that have become noxious weeds on Oahu as well as other Hawaiian Islands (Cuddihy and Stone 1990, Scott *et al.* 1986, Tomich 1986). Hilo grass rapidly forms a dense ground cover in wet habitats from sea level to 2,000 meters (6,600 feet) in elevation and competes with ferns and other native plants (Cuddihy and Stone 1990, Haselwood and Motter 1983, O'Connor 1990, Smith 1985). Its small hairy seeds are easily transported on humans and animals or carried by the wind through native forests. Hilo grass threatens the following three Oahu plant taxa: *Chamaesyce deppeana*, *Hesperomannia arborescens,* and *Viola oahuensis* (USFWS 1996a, 1996b).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998).

Common ironwood is a large, fast-growing tree that reaches up to 20 meters (65 feet) in height (Wagner *et al.* 1990). This large tree shades out other plants, takes up much of the available nutrients, and possibly releases a chemical agent that prevents other plants from growing beneath it (Smith 1985). Like Hilo grass, common ironwood is becoming a significant component of the wet forest vegetation in Nuuanu Valley and poses a significant threat to *Chamaesyce deppeana* (USFWS 1996a).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998).

Huehue haole, a vine native to tropical America, is found in dryland habitats and mesic forest on Oahu, Maui, and Hawaii, where it thrives in the subcanopy layers and smothers shrubs, small trees, and the ground layer (Escobar 1990, Smith 1985, Wester 1992). Huehue haole threatens one or more populations of the following nine plants in the Waianae Mountains: *Abutilon sandwicense, Chamaesyce herbstii, Diellia falcata, Diellia unisora, Gouania vitifolia, Melicope saint-johnii, Neraudia angulata, Schiedea kaalae,* and *Urera kaalae* (USFWS 1995, 1996b).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998).

Maui pamakani and **Hamakua pamakani**, both native to tropical America, have naturalized in dry areas to wet forest on Oahu and four other islands (Wagner *et al.* 1990).

These two noxious weeds form dense mats with other alien plants and prevent regeneration of native plants (Anderson *et al.* 1992). Nine of the plant taxa in both Oahu mountain ranges are threatened by competition with Maui pamakani and/or Hamakua pamakani: *Cyanea acuminata, Hedyotis parvula, Lepidium arbuscula, Lobelia monostachya, Melicope saint-johnii, Lobelia niihauensis, Pritchardia kaalae, Schiedea kaalae,* and *Viola chamissoniana* ssp. *chamissoniana* (USFWS 1996b).

The most successful biological control agent used for suppression of Hamakua pamakani infestations is the fungus *Entyloma ageratinae*. It was introduced from Jamaica in 1974 by Dr. Trujillo of the University of Hawaii. After its release in 1975, it quickly became established on Oahu and Hawaii. This fungus significantly reduced Hamakua pamakani infestations on rangelands on the island of Hawaii. In addition, HDOA released three insects for control of this weed. A tephritid fly, *Xanthaciura connexionus*, was introduced from Mexico in 1955, but it did not become established. In 1973, another tephritid, *Procecidochares alani*, was also introduced from Mexico. This species, known in Hawaii as the Hamakua pamakani gall fly, became established on Oahu and Hawaii and has contributed to the suppression of infestations of the weed, particularly in drier habitats that are not favorable for the fungus. The Hamakua pamakani plume moth, *Oidaematophorus beneficus*, was also introduced from Mexico in 1973. This pterophorid moth is established in wetter habitats on Hawaii, but it is difficult to determine its effectiveness as it thrives in the same wet habitat as the *Entyloma* fungus (M. Isherwood, pers. comm. 1998).

The eupatorium gall fly, *Procecidochares utilis*, was introduced from Mexico in 1944 for control of Maui pamakani, known in other parts of the world as crofton weed and known as *Eupatorium adenophorum* until it was reassigned to *Ageratina.* This tephritid fly became established on Maui, where the weed was known to have been introduced and where it was most prevalent, and has been credited with nearly complete suppression of Maui pamakani infestations in the islands (M. Isherwood, pers. comm. 1998).

Air plant is an herb that occurs on all the main islands except Niihau and Kahoolawe, especially in dry to mesic areas (Wagner *et al.* 1990). Air plant poses a significant threat to the only population of *Lobelia monostachya* (USFWS 1996b).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998).

Shoebutton ardisia (*Ardisia elliptica*), a branched shrub growing up to 4 meters (11 feet), threatens a population of *Eugenia koolauensis* by forming dense monotypic stands (USFWS 1996a).

No biological control agents have been released for this species (M. Isherwood, pers. comm. 1998)

Fire

Fire is a definite and immediate threat to 22 of the 66 plant taxa and poses a possible threat to 14 other taxa. Because Hawaii's native plants have evolved with only infrequent, naturally occurring episodes of fire (lava flows, infrequent lightning strikes), most are not adapted to fire and are unable to recover well after recurring, human-set fires. Some alien plants are more fire-adapted than the natives and will quickly exploit suitable habitat after a fire (Cuddihy and Stone 1990). Species that grow in dry and mesic vegetation may be susceptible to fires set accidentally or maliciously, especially near areas of habitation from which fires could easily spread.

Fire threatens plants upslope from Makua Military Reservation and Schofield Barracks, where current military firing exercises could unintentionally ignite fires. Within a 14-month period in 1989 and 1990, for example, a total of 10 fires resulted from firing activities in the Makua Military Reservation. Of these, 8 occurred outside of the firebreak installed by the Army. A 300-acre (120-hectare) fire in July 1989 may have destroyed a population of *Neraudia angulata*, and came within 0.25 miles (0.4 kilometers) of a population of *Nototrichium humile*. On June 14, 1995, the Army conducted a prescribed burn at Makua that got out of control and burned approximately 75 percent of the valley (USFWS, unpublished report 1995). It was determined that some individuals from five Oahu plant taxa (*Lipochaeta tenuifolia, Lobelia niihauensis, Neraudia angulata, Nototrichium humile,* and *Tetramolopium filiforme*) were burned in the fire (exactly how many individuals is undeterminable). Although most fires have been contained within a 0.02-acre (0.01-hectare) area, fires in 1989 and 1995 provide evidence of their potential to escape into the fire-prone habitat of some plant taxa in this recovery plan (Carr 1982, St. John 1981, USFWS 1995).

Fire is a potential threat on the Naval Magazine lands at Lualualei. If the Navy is unable to control a fire, it could burn up to the ridgelines of the valley, possibly affecting six of the taxa in this recovery plan (*Chamaesyce kuwaleana*, *Lipochaeta lobata* var. *leptophylla*, *Phyllostegia mollis*, *Schiedea kaalae*, *Silene perlmanii*, and *Tetramolopium lepidotum* ssp. *lepidotum*) (USFWS 1995, 1996b).

Fire is also a threat on the southeast and southwest sides of the Waianae Mountains. Arson and agricultural fires have burned up to 1,600 feet (485 meters) elevation in recent years. Arson fires occur regularly all along the Waianae Coast, including some significant areas burned just north of the Makua Military Reservation (Barrie Morgan, (TNCH), pers. comm. 1997).

In the past 14 or 15 years, approximately 8 to 10 fires occurred in conservation districts under the jurisdiction of the Hawaii DOFAW in the low elevation slopes of the Koolau Mountains (USFWS 1996a). Although the fires were contained within small areas, the possibility remains for such fires to spread upslope into habitat occupied by the endangered species, especially in dry summer months. Fires have been reported from dry and mesic regions in the Koolau Mountains, threatening *Chamaesyce deppeana* and *Hesperomannia arborescens* (USFWS 1996a). Although the extent of fire on Nuuanu Pali is not known, it is possible for a fire in the vicinity of the only known *Chamaesyce deppeana* population to spread, fueled by the combination of alien, naturalized grasses and brisk updrafts, typical of the area.

<u>Human Impacts</u>

On Oahu, habitat disturbance caused by human activities may threaten rare plant populations that grow where military training exercises and ground maneuvers are occasionally conducted. However, because most of the taxa grow on moderate to steep slopes, ridges, and gulches, habitat disturbance is probably restricted to foot and helicopter traffic. Trampling by ground troops associated with training activities and construction, maintenance, and use of helicopter landing zones could affect many recovery plan plant taxa (USFWS 1995, 1996a, 1996b).

Unrestricted collecting for scientific or horticultural purposes and excessive visits by individuals interested in seeing rare plants could result from increased publicity. Collecting and visits potentially threaten all of the endangered species, but especially to the 50 taxa with small numbers of populations and individuals (Table 3). Any unregulated collection of whole plants or reproductive parts of any of these species could adversely impact the gene pool and threaten the species' survival. The proximity of approximately 30 percent of the known individuals of *Chamaesyce deppeana* to a major scenic lookout, some within 5 meters (15 feet) of heavy pedestrian traffic, threatens a significant proportion of the entire species (USFWS 1996a). The Army is attempting to reroute mountain bike trails away from a population of *Eugenia koolauensis* to reduce trampling (Kapua Kawelo, U.S. Army Garrison, pers. comm. 1997). One population of *Hesperomannia arborescens* is close to a trail and is thus easily accessible to visitors (USFWS 1996a). Other species are potentially threatened due to trampling as hunters use an area (USFWS 1996a).

Insects

The black twig borer (*Xylosandrus compactus*) is known to threaten the Kapakai Gulch population of *Gardenia mannii* (USFWS 1996b), as well as possibly affecting populations of *Abutilon sandwicense*, *Melicope lydgatei*, and *Melicope saint-johnii*. The black twig borer burrows into branches and introduces a pathogenic fungus, most likely the ambrosia fungus (*Fusarium solani*), pruning the host severely and often killing branches or whole plants (Howarth 1985; J. Nakatani, Hawaii State Board of Agriculture, *in litt.* 1996). The black twig borer is a pest of a number of threatened and endangered plants, and a serious pest of a number of economically important plants in Hawaii (J. Nakatani, *in litt.* 1996). Several parasitoids have been introduced to control the beetle, though none of them have become established. Further research on biological control of the beetle will need to proceed cautiously as a number of rare native Hawaiian scolytids are closely related to the black twig borer (Patrick Conant, Hawaii Department of Agriculture, pers. comm. 1997; J. Nakatani, *in litt.* 1996).

Sophonia rufofascia (two-spotted leafhopper) is a threat to *Cyanea grimesiana* ssp. *obatae*, *Diellia falcata*, and *Diellia unisora,* and the surrounding ecosystem. It was introduced to Hawaii in the late 1980's and has been found on all of the major Hawaiian Islands. The two-spotted leafhopper injects toxins while feeding which causes yellowing and wilting around the feeding area on a plant (USFWS 1995). It appears to feed on almost all plant species, native and introduced. (USFWS 1995). Anecdotal observations suggest that this insect is experiencing some natural biological control exerted by locally established native egg parasites. The Hawaii Department of Agriculture (HDOA) has conducted some exploratory work in China as well as cooperative work in Viet Nam to search for natural enemies of this pest but has not had success. Currently, funding to continue searching for natural enemies of the two-spotted leafhopper is not anticipated by the HDOA (M. Isherwood, pers. comm. 1997).

Snails and Slugs

Little is known about the predation of certain rare Hawaiian plants by alien snails and slugs. Field botanists have observed slugs preying indiscriminately on plants belonging to the bellflower family (USFWS 1996b). The effect of these alien predators on the decline of *Cyanea* species (which are in the bellflower family) and related species is unclear, although slugs may pose a threat by feeding on seedlings, stems, and fruit, thereby reducing the vigor of the plants and limiting regeneration (USFWS 1996b). Members of the genus *Cyrtandra* in the family Gesneriaceae are also thought to be susceptible to slug predation. Slugs and snails apparently consume *Schiedea* seedlings in mesic or wet sites. Feeding by slugs and snails has not been documented on plants in this recovery plan, but is documented on *Schiedea membranacea*, a mesic forest species from Kauai. *Schiedea* occurring in dry areas produce abundant seedlings following winter rains, presumably because there are fewer alien consumers in the drier sites (Stephen Weller, Univ. of California, Irvine, pers. comm. 1997).

Substrate Loss

Erosion, landslides, and rockslides due to natural weathering result in habitat destruction as well as the death of individual plants. This especially affects the continued existence of taxa or populations with limited numbers and/or narrow ranges on cliffs, such as the Kaena Point population of *Schiedea kealiae*, *Sanicula mariversa*, and the remaining population of *Cyanea pinnatifida* (USFWS 1996b).

Vulnerability Due to Low Numbers

Most of these taxa have only a small number of populations and individuals, which increases the potential for extinction due to mass mortality from randomly-occurring natural causes. The limited gene pool may depress reproductive vigor, or a single human-caused or natural environmental disturbance could destroy a significant percentage of the individuals or the only known extant population. Recovery of some species may be severely limited, such as *Cyanea truncata*, *Cyrtandra crenata, Silene perlmanii,* and *Stenogyne kanehoana*, which have no known extant individuals. Four of the plant taxa in this recovery plan, *Chamaesyce deppeana*, *Cyanea superba, Cyanea pinnatifida*, and *Lobelia monostachya* are known from a single population. Six of the extant Oahu plant taxa, *Cyanea pinnatifida, Cyanea superba, Cyrtandra polyantha*, *Eragrostis fosbergii, Lobelia monostachya,* and *Phlegmariurus nutans*, are estimated to number no more than 10 individuals. Many of the remaining taxa are known from only two to five populations and/or are estimated to number no more than 100 known individuals.

Table 3. Summary of Threats to the Oahu Plants Recovery Plan taxa.

SPECIES	ALIEN MAMMALS				ALIEN PLANTS	SOIL LOSS	FIRE	HUMAN IMPACTS	INVERTE-BRATES	LIMITED NUMBERS
	Cattle	Goats	Pigs	Rats						
Abutilon sandwicense	X	X	X		X		X	X	I	
Alsinidendron obovatum			X		X			X		X1,3
Alsinidendron trinerve			X		X			X		X1
Chamaesyce celastroides var. kaenana					X		X	X		
Chamaesyce deppeana					X		X	P		X1,3
Chamaesyce herbstii			X		X		P			X1
Chamaesyce kuwaleana					X		X			X1
Chamaesyce rockii			X		X			P		
Cyanea acuminata			X	P	X			P	S	X3
Cyanea crispa			X	X	X				S	X1,3
Cyanea grimesiana ssp. obatae			X	X	X				S, I	X1,3
Cyanea humboldtiana			X	P	X			X	S	X1
Cyanea koolauensis			X	P	X			X	S	X3
Cyanea longiflora			X	P	X		P	P	S	X1
Cyanea pinnatifida			P	P	P	X		X	S	X1,2
Cyanea st.-johnii			X	P	X			X	S	X3
Cyanea superba			X	X	X		P	X	S	X1,2
Cyanea truncata			X	X	X				S	X4

Table 3, continued

SPECIES	ALIEN MAMMALS				ALIEN PLANTS	SOIL LOSS	FIRE	HUMAN IMPACTS	INVERTE-BRATES	LIMITED NUMBERS
	Cattle	Goats	Pigs	Rats						
Cyrtandra crenata			X	X	X				S	X4
Cyrtandra dentata				P	X		P		S	X1,3
Cyrtandra polyantha			X	X	X				S	X1,2
Cyrtandra subumbellata				P	X			P	S	X1,3
Cyrtandra viridiflora			X	P	X			P	S	X1,3
Delissea subcordata		X	X	P	X		P	P	S	X3
Diellia falcata	X	X	X		X		X		P (I)	
Diellia unisora			X		X				P (I)	X1
Dubautia herbstobatae		X	X		X		X	X		X1
Eragrostis fosbergii		X	X		X		X	X		X1,2
Eugenia koolauensis			X		X			X		X1
Gardenia mannii			X	P	X		P	P	I	X3
Gouania meyenii		X	X		X		X			X1,3
Gouania vitifolia			X		X		P			X1,2
Hedyotis degeneri			X		X					X1,3
Hedyotis parvula		X	X		X		X	X		X1
Hesperomannia arborescens		X	X		X		X	X		X3
Hesperomannia arbuscula			X		X			X		X3
Labordia cyrtandrae			X	X	X		P	P		X1,3

Table 3, continued

SPECIES	ALIEN MAMMALS				ALIEN PLANTS	SOIL LOSS	FIRE	HUMAN IMPACTS	INVERTE-BRATES	LIMITED NUMBERS
	Cattle	Goats	Pigs	Rats						
Lepidium arbuscula		X			X		P	X		
Lipochaeta lobata var. leptophylla		X			X		X			X1,3
Lipochaeta tenuifolia		X	X		X		X			X1
Lobelia gaudichaudii ssp. koolauensis			X	P	X			X	P (S)	X1
Lobelia monostachya				X	X				S	X1,2
Lobelia niihauensis		X		P	X		X	X	S	
Lobelia oahuensis			X	X	X				S	X
Melicope lydgatei			X		X				P (I)	X1,3
Melicope saint-johnii		X	X		X		P		P (I)	X1
Myrsine juddii			X		X			P		X1
Neraudia angulata	P	X	X		X		X	X		X
Nototrichium humile	X	X	X		X		X	X		
Phlegmariurus nutans			X		X					X1,2
Phyllostegia hirsuta			X		X			P		
Phyllostegia kaalaensis			X		X		P			X1,2
Phyllostegia mollis			X		X					X1
Pritchardia kaalae		X	X	X	X		P	P		X1
Sanicula mariversa		X			X	X	X	X		X1,3
Schiedea kaalae		X	X		X		X		S	X1,3

Table 3, continued

SPECIES	ALIEN MAMMALS				ALIEN PLANTS	SOIL LOSS	FIRE	HUMAN IMPACTS	INVERTE-BRATES	LIMITED NUMBERS
	Cattle	Goats	Pigs	Rats						
Schiedea kealiae					X	X	X		S	X1
Silene perlmanii			X		X					X4
Stenogyne kanehoana			P		X		P			X4
Tetramolopium filiforme		X			X		X	X		X1
Tetramolopium lepidotum ssp. *lepidotum*		X	X		X		X	X		X1,3
Tetraplasandra gymnocarpa			X		X					X
Trematolobelia singularis			X	P	X				S	X1
Urera kaalae			X		X		X			X3
Viola chamissoniana ssp. *chamissoniana*		X	X		X		X			X3
Viola oahuensis			X		X			P		X

KEY

X = Immediate and significant threat
P =Potential threat
S = Slugs and snails
I = Insects
1 = 5 or fewer populations
2 = 10 or fewer individuals
3 = 100 or fewer individuals
4 = No known populations or wild individuals

D. Overall Conservation Efforts

Federal and State

The taxa covered by this plan were added to the Federal list of endangered and threatened plants at various times as endangered species (USFWS 1991a, 1991b, 1992, 1994a, 1994b, 1996b). Critical habitat was not designated for any of the taxa in the Oahu plant cluster. Such designation was not deemed prudent because the mandated publication of precise critical habitat maps could increase threats to the plants by vandalism, researchers, curiosity seekers, or collectors of rare plants.

When a species is listed as endangered or threatened under the Endangered Species Act of 1973, as amended (ESA), it is automatically added to the State of Hawaii's list of protected species (Hawaii Revised Statutes Chapter [HRS] 195D). Hawaii State law prohibits taking of endangered flora and encourages conservation by State government agencies. ("Take" as defined by Hawaii State law means "to harass, harm . . ., wound, kill . . ., or collect endangered or threatened . . . species . . . or to cut, collect, uproot, destroy, injure, or possess endangered or threatened . . . species of . . . land plants, or to attempt to engage in any such conduct" [HRS 195D]). The ESA offers additional protection to these taxa since it is a violation of the ESA for any person to remove, cut, dig up, or damage or destroy an endangered plant in an area not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law [Section 9(a) (2) of the ESA].

Plants covered by this plan occur on Federal lands on portions of Schofield Barracks Military Reservation, Makua Military Reservation, and Dillingham Military Reservation, under the jurisdiction of the U.S. Army, and Lualualai Naval Magazine, under the jurisdiction of the U.S. Navy. Plants in this plan also occur on private land that is leased to the U.S. Army. Federal agencies are required by section 7 of the ESA to insure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any endangered or threatened species. Section 7 further stipulates that all Federal agencies utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of listed species. Such programs are subject to landowner approval on leased land.

Many species of the Oahu plant cluster occur on land owned or leased by the U.S. Army for training installations. In the Waianae Mountains, the Army owns Makua Military Reservation and Schofield Barracks Military Reservation, West and South Ranges. In the

Koolau Mountains, Schofield Barracks Military Reservation, East Range, is owned by the Army, and Kawailoa and Kahuku Training Areas are leased to the Army.

The Army uses portions of the Waianae installations for maneuver and live-fire training as well as explosive ordnance operations. Entry into these installations by personnel is limited to prevent injury from unexploded ordnance. The Army uses its Koolau training installations for mountain and jungle warfare training as well as tactical maneuver training with both rotary and fixed wing aircraft operations. The listed plants that occur on these installations are found outside the target areas and may not be directly affected by military activities. However, indirect threats such as the introduction of exotic species and munitions-induced fire remain significant.

The Army contracted The Nature Conservancy of Hawaii to prepare biological inventories of its training installations. Based on these surveys, the Army drafted Endangered Species Management Plans and has developed a program to implement conservation measures (K. Kawelo, pers. comm. 1997). The Army is attempting to manage its endangered species on a species level (monitoring, small exclosures, predator control, collection for propagation) and on an ecosystem level. Some major ecosystem level projects undertaken by the Army are fire control via construction of dip ponds, new fuel breaks, and realignment of targets to minimize the risk of igniting fires in vegetation outside fuelbreaks (K. Kawelo, pers. comm. 1997). The Army is also trying to control ungulates in Makua Military Reservation and has constructed a fence along Makua Valley's southwestern and eastern rims to keep goats from a neighboring ranch from entering biologically significant areas. Completion of the fence on the southeastern rim is in the planning stages. Additionally, the Army has constructed a pig exclosure in Kahanahaiki Valley to protect a sensitive area of mesic forest. The Army is mapping and selectively controlling weeds in areas of biological concern and has implemented hunting programs in the Waianae training installations (K. Kawelo, pers. comm. 1997). Hunting, however, is extremely limited due to unexploded ordnance concerns.

At Lualualei Naval Reservation, several populations of Oahu plant cluster taxa have been fenced by the Navy, and there is an on-going weed removal program for these fenced areas (HHP 1997). Several populations of Oahu plant cluster taxa are also in unfenced, natural management areas, which are areas set aside for conservation.

The U.S. Fish and Wildlife Service is studying the feasibility of establishing a National Wildlife Refuge unit in the Koolau Mountains for the conservation and management of native biodiversity, including a number of endangered species (Phyllis Ha, USFWS, pers. comm. 1997). Because alternatives are being considered for the refuge design, it is not yet possible to ascertain which species would be protected within the boundaries of a National Wildlife Refuge.

The Oahu plant taxa are generally low in numbers and occur in extremely rough and inaccessible terrain. Thus, site visits are infrequent and management actions, such as fencing and weed removal, are difficult at best. In 1994, the Division of Forestry and Wildlife hired a plant specialist, Bill Garnett, to carry out conservation measures for Oahu plants, including fence construction, seed collection, propagation, and outplanting. In addition, the Division of Forestry and Wildlife controls pigs and goats in the Koolau and Waianae Mountains by hunting and other methods, and weed removal in Natural Area Reserves (NARs), such as Pahole, Mt. Kaala, and Kaena Pt. (Randy Kennedy, DOFAW, pers. comm. 1997).

The State of Hawaii and the USFWS have provided funding to botanical gardens and research facilities:

- the National Tropical Botanical Garden (NTBG), which stores and propagates taxa of the Oahu plant cluster and many other endangered and threatened plants,
- Lyon Arboretum, which is developing tissue culture techniques, and
- the National Seed Storage Lab, which is working on seed storage methods.

Private

Seeds of some of these taxa have been collected and stored or propagated by the National Tropical Botanical Garden and the Hawaii Plant Conservation Center (HPCC), on the island of Kauai, Hawaii. The Lyon Arboretum and the Waimea Arboretum, both on the island of Oahu, have also propagated many species of the Oahu plant cluster. Table 4 presents the holdings and propagation success of the Oahu plant cluster taxa at the National Tropical Botanical Garden, Lyon Arboretum, and the Waimea Arboretum, as of July 1, 1997 (Greg Koob, Lyon Arboretum; David Orr, Waimea Arboretum; Sylvia Smith and Melany Chapin, NTBG; pers. comms. 1997).

Fourteen of the 66 plants treated in this recovery plan are maintained in *ex situ* holdings in the three botanical institutions cited above as components of the Center for Plant Conservation's (CPC) National Collection of Endangered Plants; six more have been proposed for accession into this collection and more are under consideration for proposal. These 14 taxa are subject to the Center's national collecting and genetic management guidelines for *ex situ* holdings. The Center has cooperates with the Service and other agencies and organizations wishing to undertake actions associated with the controlled propagation of listed plants. Many conservation, research, education, monitoring, and restoration projects associated with all 66 taxa are being prioritized and coordinated by the Hawaii Rare Plant Restoration Group, a body chaired by CPC-Hawaii.

A long-range management plan for Honouliuli Preserve has been drafted by TNCH. It will include actions for alien plant management, ungulate control, fire control, rare species recovery, and native habitat restoration (TNCH 1997). It is expected that these actions will benefit many Oahu plant cluster taxa within the Preserve. In addition, TNCH expects to begin construction of several miles of pig-proof fencing in Palawai Gulch that will enclose approximately 90 acres of rare plant habitat in 1998. Many Oahu plant cluster taxa are reported to be in the Palawai project area, including *Schiedea kaalae, Phyllostegia mollis, Melicope saint-johnii, Diellia falcata, and Delissea subcordata.* TNCH also constructed three exclosures in the Honouliuli Preserve in 1994 in which the following Oahu plant cluster taxa were outplanted: *Delissea subcordata, Nototrichium humile, Tetramolopium lepidotum* ssp. *lepidotum, and Urera kaalae* (W. Fulks, pers. comm. 1997). These outplantings were made within fenced exclosures where there is on-going weed, slug, and rodent control.

Table 4. Seeds, seedlines, and plants of the Oahu plants in storage/propagation at private botanical gardens or university research facilities. NTBG = National Tropical Botanical Garden. LA = Lyon Arboretum. WA = Waimea Arboretum.

Taxon	total number of seeds			plants propagated (Yes [Y] or No [N]) and number of plants propagated, if known		
	NTBG	LA	WA	NTBG	LA	WA
Abutilon sandwicense	183	0	50	Y	N	23
Alsinidendron obovatum	12585	0	0	Y	54	N
Alsinidendron trinerve	4000	35	200	Y	344	14
Chamaesyce celastroides var. kaenana	174	0	0	Y	N	N
Chamaesyce deppeana	115	0	0	Y	N	N
Chamaesyce herbstii	0	0	0	Y	N	N
Chamaesyce kuwaleana	75	0	0	Y	N	N
Chamaesyce rockii	0	139	0	N	5	N
Cyanea acuminata	450	151	0	N	211	N
Cyanea crispa	0	240	0	Y	151	N
Cyanea grimesiana ssp. obatae	16000	0	0	Y	347	N
Cyanea humboldtiana	0	0	0	N	14	N
Cyanea koolauensis	0	0	0	N	N	N
Cyanea longiflora	0	90	0	Y	Y	N
Cyanea pinnatifida	0	0	0	Y	119	N
Cyanea saint-johnii	0	0	0	N	N	N
Cyanea superba	0	10	0	Y	37	N
Cyanea truncata	0	0	0	N	N	N
Cyrtandra crenata	0	0	0	N	N	N
Cyrtandra dentata	0	3	0	N	Y	N
Cyrtandra polyantha	0	0	0	N	N	N
Cyrtandra subumbellata	0	0	0	Y	25	N

Table 4, continued

Taxon	total number of seeds			plants propagated (Yes [Y] or No [N]) and number of plants propagated, if known		
	NTBG	LA	WA	NTBG	LA	WA
Cyrtandra viridiflora	0	175	0	N	192	N
Delissea subcordata	11252	1075	0	Y	99	1
Deillia falcata	50	0	0	N	N	N
Diellia unisora	0	0	0	N	N	N
Dubautia herbstobatae	2	90	0	N	N	N
Eragrostis fosbergii	0	0	0	N	N	N
Eugenia koolauensis	0	36	0	N	N	5
Gardenia mannii	2000	0	0	Y	1477	N
Gouania meyenii	51	1	0	Y	Y	N
Gouania vitifolia	0	0	0	Y	N	N
Hedyotis degeneri	1300	0	0	Y	26	N
Hedyotis parvula	2100	7	0	Y	312	N
Hesperomannia arborescens	250	0	0	Y	31	N
Hesperomannia arbuscula	200	0	0	Y	Y	N
Labordia cyrtandrae	0	525	0	N	N	N
Lepidium arbuscula	36	0	0	Y	N	N
Lipochaeta lobata var. leptophylla.	100	10	0	Y	Y	N
Lipochaeta tenuifolia	127	7	0	Y	Y	N
Lobelia gaudichaudii ssp. koolauensis	8400	0	0	N	N	N
Lobelia monostachya	0	25	0	N	Y	N
Lobelia niihauensis	500	0	0	Y	N	N
Lobelia oahuensis	4700	0	0	N	809	N
Melicope lydgatei	0	0	0	N	15	N
Melicope saint-johnii	0	0	0	N	N	N
Myrsine juddii	686	0	0	N	N	N

Table 4, continued

Taxon	total number of seeds			plants propagated (Yes [Y] or No [N]) and number of plants propagated, if known		
	NTBG	LA	WA	NTBG	LA	WA
Neraudia angulata	234	0	0	Y	N	N
Nototrichium humile	3582	0	0	N	N	9
Phlegmariurus nutans	0	0	0	Y	N	N
Phyllostegia hirsuta	660	0	0	Y	23	N
Phyllostegia kaalaensis	0	0	0	Y	N	N
Phyllostegia mollis	0	0	0	Y	Y	N
Pritchardia kaalae	0	0	0	Y	38	5
Sanicula mariversa	0	120	0	Y	N	N
Schiedea kaalae	0	14	0	Y	55	9
Schiedea kealiae	277	0	0	Y	N	19
Silene perlmanii	200	0	0	Y	200	N
Stenogyne kanehoana	0	0	0	Y	N	N
Tetramolopium filiforme	1450	105	0	Y	N	N
Tetramolopium lepidotum ssp. lepidotum	2400	0	0	Y	N	N
Tetraplasandra gymnocarpa	0	N	0	N	N	N
Trematolobelia singularis	0	0	0	N	N	N
Urera kaalae	1027	45	0	Y	N	Y
Viola chamissoniana ssp. chamissoniana	100	82	0	Y	N	N
Viola oahuensis	0	0	0	Y	N	N

5. Species Accounts

The following are individual species accounts for the Oahu plant cluster taxa. Figures depicting the current and historical ranges of each taxon are found in Appendix C. Descriptions of the taxa and taxonomic explanations may be found in the final rules listing them as endangered species (USFWS 1991a, 1991b, 1992, 1994a, 1994b, 1996b). The Recovery Priority System is described in Appendix D.

Any known immediate, species-specific recovery actions can be found in the account for that species. Concurrent with and following these immediate preservation measures, long-term recovery actions should be implemented as specified in the Stepdown Narrative. The general strategy for the recovery of these species can be found in the Overall Recovery Strategy section, immediately following the Species Accounts section.

Abutilon sandwicense Recovery Priority Number 8

Appendix B contains a line drawing of *Abutilon sandwicense.*

a. Life History

Abutilon sandwicense has been observed flowering in winter and spring. By summer, most plants have flowered and the fruits have usually dried up by fall. Fruit capsules develop within six weeks. Although seedlings are often initially abundant, few plants appear to survive to maturity for unknown reasons (USFWS 1995).

b. Habitat Description

Abutilon sandwicense typically grows on steep slopes or gulches in dry to mesic lowland forest at an elevation of 300 to 600 meters (1,000 to 2,000 feet) (USFWS 1995). Associated plants include *Diospyros* spp. (lama), *Pipturus albidus* (mamaki), *Elaeocarpus bifidus* (kalia), *Sapindus oahuensis* (aulu), *Nestegis sandwicensis* (olopua), and *Psydrax odoratum* (alahee) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Abutilon sandwicense* was known from nearly the entire length of the Waianae Mountains, from Makaleha Valley to Nanakuli Valley (Bates 1990). This species is now known from Makaleha Valley east to Palikea Gulch, south to Nanakuli Valley, and Makaha-Waianae Kai Ridge on State, Federal, City/County, and privately owned land (HHP 1997). The 14 known populations are found in an area about 8 by 16 kilometers (5 by 10 miles) and contain fewer than 300 individuals (HHP 1997). Ten of these populations number fewer than 10 individuals each, and the remaining four populations number between 30–100 individuals each.

d. Reasons for Decline and Current Threats

The major threats to *Abutilon sandwicense* are competition from alien plant species (Christmas berry, kukui, Koster's curse, molasses grass, and huehue haole), fire, and trampling by goats, pigs, and cattle (USFWS 1995). Cultivated plants of *Abutilon sandwicense* are also affected by the black twig borer (J. Lau, pers. comm. 1997).

e. Conservation Measures

TNCH is monitoring and controlling alien weeds around one population of *Abutilon sandwicense* in Honouliuli Preserve at Huliwai Gulch. The 11 plants in this population appear to be healthy, but they are threatened by huehue haole as well as human activity on an adjacent trail (Jennifer Crummer, TNCH, pers. comm. 1997).

Abutilon sandwicense is targeted for outplanting by DOFAW at Pahole Natural Area Reserve (NAR) (B. Garnett, pers. comm. 1997). It is also being successfully propagated at the National Tropical Botanical Garden and the Waimea Arboretum (D. Orr and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the known populations of *Abutilon sandwicense* on State, Federal, and private land to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Additionally, specific efforts should be made to immediately fence and protect those populations that have only a few remaining individuals. Populations with fewer than 10 individuals are located at Mt. Kaala, Puuiki Ridge, Huliwai Gulch, Makaleha, Kaawa Gulch, Waianae Kai, and Lualualei. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect those populations that have only a few remaining individuals, such as within the Mt. Kaala NAR, Huliwai Gulch, and Kaawa Gulch.

3) Survey likely areas for additional populations and implement protective measures if necessary.

Additional populations or individuals are likely to be found with additional searching, especially in areas around Puu Pane in the Waianae Mountains (USFWS 1995).

4) Implement control methods for the black twig borer, based on further research into methods.

The black twig borer has been identified as a threat to cultivated individuals of *Abutilon sandwicense*. Little is known about how this plant may be affected by defoliation or reduced vigor due to infestations of this alien beetle. A number of parasitoids have been introduced to control the beetle, although none have become established. Further research on biological control of the beetle will need to proceed cautiously as a number of rare native Hawaiian scolytids are closely related to the black twig borer (P. Conant, pers. comm. 1997; J. Nakatani, *in litt.* 1996).

5) Provide protection from fire.

A coordinated fire protection plan needs to be developed and implemented for endangered plant species on State Natural Area Reserves, such as Mt. Kaala and Mokuleia NAR, and Federal lands, such as Schofield Barracks Military Reservation.

Alsinidendron obovatum Recovery Priority Number 5

Appendix B contains a line drawing of *Alsinidendron obovatum*.

a. Life History

Alsinidendron obovatum generally flowers after about two years of growth. Plants flower and fruit year round, but flowering is usually heavier in winter and spring depending on the level of precipitation. Plants survive three to six years, unless there are drought conditions (USFWS 1995).

b. Habitat Description

Alsinidendron obovatum typically grows on ridges and slopes in lowland diverse mesic forest dominated by koa and ohia at an elevation of 560 to 760 meters (1,850 to 2,500 feet) (USFWS 1995, Wagner *et al.* 1990). Associated plants include *Bidens* sp. (kookoolau), *Peperomia tetraphylla, Diospyros sandwicensis* (lama), olopua, and alahee (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Alsinidendron obovatum* is known from the northern and southern ends of the Waianae Range (Wagner *et al.* 1990). This species remains on State-owned land in Kapuna (8 individuals) and Pahole Gulches (2 populations with 1 and 2 individuals, respectively) (HHP 1997), and from Army land in Kahanahaiki Gulch (1 individual) within Makua Military Reservation (K. Kawelo, pers. comm. 1997). The four known populations contain 12 individuals (J. Lau and K. Kawelo, pers. comms. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Alsinidendron obovatum* are competition from aggressive alien plants, including Java plum and molasses grass; habitat degradation by feral pigs; collection or trampling by humans; potential fire; and the small number of populations and individuals (USFWS 1995).

e. Conservation Measures

Eight individuals have been planted in an exclosure at Pahole NAR (B. Garnett, pers. comm. 1998). Approximately 40 individuals are also retained at DOFAW's mid-elevation propagation facility in the Waianae Mountains (Nike missile site), where they have grown to maturity. These plants have been crossed and fruit has been collected from the crosses. This species is also being propagated at the National Tropical Botanical Garden and the Lyon Arboretum (S. Smith and G. Koob, pers. comms. 1997).

The Army has adopted a fire management plan, which includes realigning targets and establishing firebreaks. These actions may aid in protecting this species from the threat of fire. The one individual occurring on Makua Military Reservation has been included in a large fenced exclosure from which ungulates have been eradicated (K. Kawelo, pers. comm. 1997). This species is targeted for outplanting within the existing exclosure.

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the populations in Kapuna and Pahole Gulches to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect all remaining populations.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Pahole Gulch) and Federal lands needs to be developed and implemented.

Alsinidendron trinerve Recovery Priority Number 5

Appendix B contains a line drawing of *Alsinidendron trinerve*.

a. Life History

Alsinidendron trinerve flowers and fruits throughout the year with the possible exception of fall (USFWS 1995).

b. Habitat Description

Alsinidendron trinerve typically grows on slopes in wet forest or the wetter portions of diverse mesic forest dominated by ohia and *Ilex anomala* (kawau) at an elevation of 900 to 1,200 meters (3,000 to 4,000 feet) (USFWS 1995). Associated plants include *Coprosma* sp. (pilo), *Gunnera* (apeape), *Melicope* sp. (alani), *Cibotium* sp. (hapuu), *Antidesma platyphylla* (hame), and mamaki (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Alsinidendron trinerve* is known from the north-central and southern Waianae Mountains (USFWS 1995). This species is known to be extant in 3 populations on Mt. Kaala (100 individuals) (B. Garnett and K. Kawelo, pers. comm. 1998) and Puu Kalena (8 individuals) on federally owned land (HHP 1997). These two locations, which are about 1.6 kilometers (1 mile) apart, contain approximately 108 individuals, most of which occur at Mt. Kaala. Additional plants probably occur between Mt. Kaala and Puu Kalena (B. Garnett, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The major threats to *Alsinidendron trinerve* are competition from aggressive alien plants, particularly prickly Florida blackberry; habitat degradation by feral pigs; trampling or collection by humans along trails; and the small number of extant populations and individuals (USFWS 1995).

e. Conservation Measures

TNCH examined the Mt. Kaala population of *Alsinidendron trinerve* to determine management needs. Although the plants are threatened by feral pigs, TNCH determined that a small fence around the population would increase open trampled areas that attract pigs and create sites for weeds to become established (J. Crummer, pers. comm. 1997).

Forty to forty-five individuals of *Alsinidendron trinerve* were outplanted in a fenced and managed area in the Mt. Kaala NAR in September 1996. However these plants are not doing well, probably due to oversaturation and low pH in the soil (B. Garnett, pers. comm. 1998). There are 300+ seedlings growing at the mid-elevation nursery at the Nike missile site (B. Garnett, pers. comm. 1997). This species is also being propagated at the Lyon Arboretum, the National Tropical Botanical Garden, and the Waimea Arboretum (G. Koob, D. Orr, and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Control feral pigs.

Fencing of individual populations is not feasible because of the steep slopes (USFWS 1995). Strategic fencing of a larger area should be considered and general feral pig control measures need to be implemented (J. Crummer, pers. comm. 1997). In areas where fencing is not feasible, other ungulate control methods, such as snaring should be judiciously used.

2) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect the 3 extant populations. Manual removal will be difficult at all sites and may harm populations by opening corridors for feral pigs. Any weeding should be done with care and biocontrol options for prickly Florida blackberry need to be explored.

Chamaesyce celastroides* var. *kaenana Recovery Priority Number 9

No line drawing is available for this taxon.

a. Life History

Chamaesyce celastroides var. *kaenana* has been observed flowering and fruiting throughout the year, probably in response to precipitation. Fruits mature in 3 to 4 weeks and plants live from 5 to 10 years (USFWS 1995).

b. Habitat Description

Chamaesyce celastroides var. *kaenana* typically grows in coastal dry shrubland on windward talus slopes at an elevation of 9 to 640 meters (30 to 700 feet) (USFWS 1995). Associated taxa include *Gossypium tomentosum* (mao), *Jacquemontia ovalifolia* ssp. *sandwicensis* (pauohiiaka), *Myoporum sandwicense* (naio), *Santalum freycinetianum* (iliahi), and *Sida fallax* (ilima) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Chamaesyce celastroides* var. *kaenana* was known from the northwestern end of the Waianae Mountains and from one collection from the southeastern end of the Koolau Mountains (USFWS 1995, Koutnik and Huft 1990). This taxon remains on Federal land in the vicinity of Kaena Point (450 individuals), and on State-owned land in Alau Gulch (12 individuals), Waianae Kai (3 individuals), and Keawaula. There are 7 populations in Keawaula, 3 of which number fewer than 3 individuals each and 4 of which number between 14–26 individuals (HHP 1997). The 10 known populations, which are all located within an area of about 1.6 by 5 kilometers (1 by 3 miles), contain approximately 545 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Chamaesyce celastroides* var. *kaenana* are competition from the alien plant, koa haole; fire; and effects of recreational activities (USFWS 1995).

e. Conservation Measures

DOFAW restricted off-road vehicle access to the Kaena Point NAR by constructing a large barrier on the Mokuleia side of the reserve. Access from the Waianae side is prevented by a natural washout. Three individuals were outplanted at the Kaena Point NAR in 1995, and, as of July 1997, only one survives. Other management activities in the NAR include weeding of koa haole and kiawe in the vicinity of *Chamaesyce celastroides* var. *kaenana* and outplanting (B. Garnett and T. Takahama, pers. comms. 1997). This species is also being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Alau Gulch, Waianae Kai, and Keawaula).

2) Provide protection from fire.

A coordinated fire protection plan for endangered plants on State Natural Area Reserves and Federal lands needs to be developed and implemented.

Chamaesyce deppeana Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species has been observed in flower in May and September (Bishop Museum herbarium specimens [BISH] 19134 and 504036).

b. Habitat Description

The most visible and accessible plants within the only known population of *Chamaesyce deppeana* are confined to a 20-square-meter (200-square-foot) area, portions of which extend to within 5 meters (15 feet) of the Pali Lookout parking lot, and along the ridge crest and cliff faces on the windward side (USFWS 1996a). The remaining plants are scattered on an adjacent steep, exposed, windswept slope growing with alien grasses and shrubs (USFWS 1996a). Associated species include *Carex* sp., kookoolau, ohia, and *Eragrostis* sp. (kawelu). This population is found at an elevation of approximately 300 meters (1,000 feet) (USFWS 1996a).

c. Current and Historic Ranges and Population Status

Historically, *Chamaesyce deppeana* was known only from "southern Oahu." Because only a few collections were made, all of them before the 20th century, it was thought to be extinct (USFWS 1996a). In 1986, Joel Lau and Sam Gon of TNCH rediscovered *C. deppeana* on State land in the southern Koolau Mountains of Oahu in Nuuanu Pali Wayside State Park near the Pali Lookout, a popular tourist attraction (USFWS 1996a). Fewer than 50 individuals grow there, with such plants as ohia, kookoolau, *Casuarina equisetifolia* (common ironwood), and *Phyllanthus distichus* (pamakani mahu) (USFWS 1996a).

d. Reasons for Decline and Current Threats

The major threats to the single known population of *Chamaesyce deppeana* are competition for water, space, light, and nutrients with various alien plants such as common ironwood, Hilo grass, and Christmas berry; fire; the possibility of impact by humans; and the risk of extinction from naturally-occurring mortality due to the limited number of individuals and restricted range (USFWS 1996a).

e. Conservation Measures

Chamaesyce deppeana is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997). No additional specific conservation measures have been undertaken.

f. Needed Recovery Actions

1) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect the remaining extant population.

2) Provide protection from fire.

A coordinated fire protection plan for endangered plants on Department of State Parks land needs to be developed and implemented.

Chamaesyce herbstii Recovery Priority Number 8

No line drawing is available for this taxon.

a. Life History

This species has been observed in flower year-round in January, May, July, September, and October (BISH 642401, 430767, 456390, 50162, and 631709).

b. Habitat Description

Chamaesyce herbstii typically grows in mesic koa-ohia lowland forests, *Pisonia* sp. (papala kepau), *Charpentiera* sp. (papala) lowland forests, or diverse mesic forests at elevations between 530 and 700 meters (1,750 to 2,300 feet). Associated plants include the federally endangered *Alectryon macrococcus* var. *macrococcus* (mahoe), as well as *Hibiscus arnottianus* var. *arnottianus*
(kokio keokeo), alani, *Pouteria* sp. (alaa), and *Urera glabra* (opuhe) (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Chamaesyce herbstii* was known from scattered populations in the northern and central Waianae Mountains on the island of Oahu (HHP 1997). Currently this species is known from 4 populations in the central and northern Waianae Mountains—South Ekahanui Gulch (4 individuals), Pahole Gulch (60 individuals), Kapuna Gulch (100 individuals), and West Makaleha-Central Makaleha (10–12 individuals). These populations are found on private land in TNCH's Honouliuli Preserve and on State land in Pahole NAR (HHP 1997). The total number of plants is estimated to be fewer than 200.

d. Reasons for Decline and Current Threats

The primary threats to *Chamaesyce herbstii* are habitat degradation and/or destruction by feral pigs; competition with alien plants such as Koster's curse, silk oak, huehue haole, strawberry guava, and Christmas berry; potential fire; and risk of extinction from naturally-occurring events (such as hurricanes) and/or reduced reproductive vigor due to the small number of remaining populations (HHP 1997; C. Russell, pers. comm. 1997).

e. Conservation Measures

Fencing and removal of feral pigs in the Pahole drainage was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse continues in the surrounding areas. Plants in the Pahole drainage have been measured and mapped, and seeds have been collected from plants outside the fence for nursery cultivation and re-introduction into the fenced areas (T. Takahama, pers. comm. 1997). This species is also being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Ekahanui and West Makaleha gulches). A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Ekahanui and West Makaleha gulches).

Chamaesyce kuwaleana Recovery Priority Number 8

No line drawing is available for this species.

a. Life History

Chamaesyce kuwaleana bears fruits in spring and early summer and is usually done fruiting by the fall (USFWS 1995).

b. Habitat Description

Chamaesyce kuwaleana typically grows on arid, exposed volcanic cliffs at an elevation of 180 to 320 meters (600 to 1,050 feet) (USFWS 1995). Associated plants include ilima and *Dodonaea viscosa* (aalii) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Chamaesyce kuwaleana* is known from the central Waianae Mountains and Moku Manu Island off the eastern coast of Oahu (USFWS 1995, Koutnik and Huft 1990). It is currently known from Kauaopuu Peak (2 populations with about 500 and 1,000 individuals, respectively) and Puu Kailio (several hundred individuals), on Federal and State lands (HHP 1997). The 3 populations are 5 kilometers (3 miles) apart and contain approximately 2,000 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Chamaesyce kuwaleana* are competition from alien plants (koa haole and *Cenchrus ciliaris* [buffelgrass]), fire, and vulnerability due to the small number of populations (USFWS 1995).

e. <u>Conservation Measures</u>

This species is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997). No other specific conservation measures have been undertaken for *Chamaesyce kuwaleana*.

f. <u>Needed Recovery Actions</u>

1) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect the remaining extant populations.

2) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Waianae Kai Forest Reserve) and Federal (Lualualei Military Reservation) lands needs to be developed and implemented.

Chamaesyce rockii Recovery Priority Number 8

Appendix B contains a line drawing of *Chamaesyce rockii*.

a. <u>Life History</u>

Chamaesyce rockii has been observed fruiting in February (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. <u>Habitat Description</u>

Chamaesyce rockii typically grows in wet ohia-*Dicranopteris linearis* (uluhe) forest and shrubland between 640 and 915 meters (2,100 and 3,000 feet) in elevation (HHP 1997). Associated plants include *Dubautia laxa* (naenae pua melemele), *Machaerina* sp. (uki), *Psychotria fauriei* (kopiko), and *Wikstroemia oahuensis* (akia) (HHP 1997).

c. Current and Historic Ranges and Population Status

Chamaesyce rockii was known historically from 13 scattered populations along the Koolau Mountains on the island of Oahu (HHP 1997). Eleven known populations are extant and are found on private and Federal land. Ten of the populations are on private land leased to DOD in the Kawailoa Training Area (5 populations number fewer than 12 individuals; 5 populations number between 50–200). One population is extant on Federal land at Schofield Barracks Military Reservation (1 individual) (HHP 1997). The total number of plants is estimated to be between 200 and 400.

d. Reasons for Decline and Current Threats

The primary threats to *Chamaesyce rockii* are habitat degradation and/or destruction by feral pigs, potential impacts from military activities, and competition with alien plants, such as strawberry guava and Koster's curse (HHP 1997).

e. Conservation Measures

This species is being propagated at the Lyon Arboretum (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Chamaesyce rockii* and control or removal of pigs conducted to alleviate their impact on the native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Kaukonahua-Kahana summit, Peahinahina trail). A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Kaukonahua-Kahana summit, Peahinahina trail), and all populations once enclosed.

Cyanea acuminata Recovery Priority Number 11

Appendix B contains a line drawing of *Cyanea acuminata*

a. Life History

Cyanea acuminata has been observed fruiting in February and November (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species typically grows on slopes, ridges, or stream banks from 305 to 915 meters (1,000 to 3,000 feet) elevation. The plants are found in mesic to wet ohia-uluhe, koa-ohia, or *Diospyros sandwicensis* (lama)-ohia forest (HHP 1997, Lammers 1990).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea acuminata* was known from 31 scattered populations in the Koolau Mountains of Oahu (HHP 1997). Currently, fewer than 100 plants are known from 15 populations on City and County of Honolulu land, State land, privately-owned land (including land leased by the DOD for the Kawailoa Training Area), and Federal land on Schofield Barracks Military Reservation and the Omega Coast Guard Station (HHP 1997). Eleven populations number fewer than 10 individuals each (7 populations each contain only 1 or 2 individuals) and 4 populations number between 10–40 individuals each.

d. Reasons for Decline and Current Threats

The major threats to *Cyanea acuminata* are habitat degradation and/or destruction by feral pigs, potential impacts from military activities, potential rat and slug predation, competition with noxious alien plants (Christmas berry, prickly Florida blackberry, Koster's curse, and *Ageratina adenophora* [Maui pamakani]), and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals (HHP 1997; C. Russell and J. Lau, pers. comm. 1997).

e. Conservation Measures

This species is being propagated at the Lyon Arboretum and seeds are in storage at the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Cyanea acuminata* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Where enclosures are not feasible due to topography, other means of ungulate control such as snaring should be used judiciously. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect all those populations that have only a few remaining individuals (Kawailoa Training Area, Kaukonahua Stream, Puu Keahiakohoe, Kamanaui Valley, and Puu o Kona).

3) Reduce threat from rats.

Populations of *Cyanea acuminata* on Oahu may be seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea crispa Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species was observed in flower in April 1930 (USFWS 1996a). It was more recently been observed fruiting in June and September (K. Kawelo, personal communication 1998). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyanea crispa is found in habitats ranging from steep, open mesic forests to gentle slopes or moist gullies of closed wet forests, at elevations between 185 and 730 meters (600 and 2,400 feet) (USFWS 1996a). Associated plants include common *Cyrtandra* species (haiwale), papala kepau, and *Touchardia latifolia* (olona) (USFWS 1996a).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea crispa* was known from scattered locations throughout the upper elevations of the Koolau Mountains of Oahu from Kaipapau Valley to the north to Waialae Iki Ridge to the southeast (Skottsberg 1926 USFWS 1996a). This species is now known from Hidden Valley (26 individuals), Palolo Valley (1 individual), Kapakahi Gulch (1 individual), Pia Valley (1 individual), Kaipapau-Kawainui summit divide (5 individuals), Moanalua Valley (few) and Upper Aina Haina (4 individuals) on State, and private lands including the Kawailoa Training Area (DOD-leased), and private lands(USFWS 1996a). The 7 populations are scattered over a distance of about 31 kilometers (19 miles) and number only about 40 individuals.

d. Reasons for Decline and Current Threats

The major threats to *Cyanea crispa* are habitat alteration and suspected predation by rats, slugs, and feral pigs, competition with noxious alien plants (kukui, Koster's curse, and strawberry guava), and risk of extinction due to naturally occurring events, and/or reduced reproductive vigor due to the small number of remaining individuals, their limited gene pool, and restricted distribution (USFWS 1996a).

e. Conservation Measures

The Division of Forestry and Wildlife has undertaken a pig control program in Hidden Valley. However, a September, 1997 site visit revealed abundant pig sign with many individuals of *Cyanea crispa* defoliated or dead (K. Kawelo, personal communication 1998). This species is being propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Cyanea crispa* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Palolo Valley, Kapakahi Gulch, Pia Valley, and Upper Aina Haina). A commitment should be developed for long-term stewardship and conservation of all areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed around plants, with priority given to protecting populations that have only a few remaining individuals (Palolo Valley, Kapakahi Gulch, Pia Valley, and Upper Aina Haina).

3) Reduce threat from rats.

Most populations of *Cyanea crispa* on Oahu are seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea grimesiana* ssp. *obatae Recovery Priority Number 6

Appendix B contains a line drawing of *Cyanea grimesiana* spp. *obatae*.

a. Life History

Cyanea grimesiana spp. *obatae* flowers and fruits year round, depending on rainfall (USFWS 1995).

b. Habitat Description

Cyanea grimesiana ssp. *obatae* typically grows on steep, moist, shaded slopes in diverse mesic to wet forests at an elevation of 550 to 670 meters (1,800 to 2,200 feet) (USFWS 1995). Associated plants include mamaki, *Charpentiera* (papala), *Claoxylon sandwicense* (poola), papala kepau, koa, and various ferns (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea grimesiana* ssp. *obatae* is known from the southern Waianae Mountains from Puu Hapapa to Kaaikukai (USFWS 1995, Lammers 1990), a distance of about 6.5 kilometers (4 miles). This taxon is known to be extant in Kaluaa (4 individuals), Ekahanui (8 individuals), and North Palawai (1 individual), on Federal and private land. The 3 populations are 6.4 kilometers (4 miles apart) and contain 13 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Cyanea grimesiana* ssp. *obatae* are competition from alien plants such as Koster's curse, kukui, and Christmas berry; habitat degradation by feral pigs; predation of seeds or fruits by introduced slugs and rats; damage to flowers and stems of plants by rats; damage by the two-spotted leafhopper; risk of extinction due to naturally occurring events, and/or reduced reproductive vigor due to the small number of living individuals (USFWS 1995; J. Crummer, pers. comm. 1997).

e. Conservation Measures

TNCH fenced the population of 8 plants in Ekahanui Gulch and is controlling alien weeds and monitoring this population. Field crews count and map plants and gather basic phenological data (J. Crummer, pers. comm. 1997).

DOFAW is growing 19 individuals of *Cyanea grimesiana* ssp. *obatae* at the mid-elevation Nike missile site in the Waianae Mountains, with 10 individuals ready for planting in the Honouliuli TNCH preserve (B. Garnett, pers. comm. 1997). This species is also being successfully propagated at the National Tropical Botanical Garden and the Lyon Arboretum (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

The only population that is fenced is Ekahanui Gulch. Efforts should be made to fence and manage the remaining two extant populations at Kaluaa and North Palawai. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect all extant populations.

3) Reduce threat from rats.

The 3 populations of *Cyanea grimesiana* ssp. *obatae* on Oahu are seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea humboldtiana Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea humboldtiana*.

a. Life History

This species has been observed in flower from September through January (herbarium specimens, BISH). No further information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species is usually found in wet shrubland dominated by ohia and uluhe from 550 to 960 meters (1,800 to 3,150 feet) elevation. Associated native plants include ferns, alani, uki, kawau, *Syzygium sandwicensis* (ohia ha), alani, *Broussaisia arguta* (kanawao), *Psychotria mariniana* (kopiko), uluhe, and *Scaevola mollis* (naupaka kuahiwi) (USFWS 1996b and BISH herbarium specimens).

c. Current and Historic Ranges and Population Status

Cyanea humboldtiana was known historically from 17 populations from the central portion to the southern end of the Koolau Mountains of Oahu (HHP 1997). Currently, between 125 and 225 plants are known from 3 populations—Konahuanui summit (20 individuals), Moanalua-Kaneohe summit (100–200 individuals), and Lulumahu Gulch (fewer than 5 individuals). These populations occur on State and private land (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Cyanea humboldtiana* are habitat degradation and/or destruction by feral pigs, potential predation by rats and slugs, competition with the alien plant Koster's curse, and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor, due to the small number of remaining populations. The Konahuanui summit population also is threatened by trampling by hikers (HHP 1997; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

This species is being propagated at the Lyon Arboretum (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made weed and protect populations with priority given to populations that have only a few remaining individuals (Konahuanui summit and Lulumahu Gulch).

3) Reduce threat from rats.

Populations of this species on Oahu may be seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea koolauensis Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea koolauensis*

a. Life History

Cyanea koolauensis has been observed in flower and fruit during the months of May through August (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyanea koolauensis usually is found on slopes and ridge crests in wet ohia-uluhe forest or shrubland at elevations from 520 to 810 meters (1,700 to 2,660 feet) (USFWS 1996b). Associated plants include alani, hame, *Diplopterygium pinnatum* (uluhe lau nui), uluhe, *Psychotria* spp. (kopiko), ohia ha, kanawao, akia, kookoolau, naenae, hapuu, *Sadleria* sp. (amau), and naupaka kuahiwi (USFWS 1996b; Lammers 1990).

c. Current and Historic Ranges and Population Status

Cyanea koolauensis was known historically from about 30 scattered populations throughout the Koolau Mountains on Oahu (HHP 1997). Currently, approximately 22 populations totaling fewer than 80 plants are known from the Waimea-Malaekahana Ridge to Hawaii Loa Ridge in the Koolau Mountains. These populations occur on City and County of Honolulu land, State land, and private land, including land leased to the DOD for the Kahuku and Kawailoa Training Areas (HHP 1997). Only two populations have as at least 10 individuals (Lulumahu Stream and Kawainui-Kaipapau divide).

d. Reasons for Decline and Current Threats

Cyanea koolauensis is threatened by habitat destruction by feral pigs, potential impacts from military activities, potential predation by rats and slugs, competition with aggressive alien plants (Koster's curse and strawberry guava), trampling by hikers, overcollection, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals (HHP 1997; J. Lau, C. Russell, and Loyal Mehrhoff, USFWS, pers. comm. 1997).

e. Conservation Measures

No specific conservation measures have been undertaken for *Cyanea koolauensis*.

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Cyanea koolauensis* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Additionally, specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Kawailoa Training Area, Poamoho-Helemano Ridge, Hawaiiloa Ridge, and Halawa Ridge Trail). In areas where fencing is not feasible, other means of ungulate control, such as snaring should be implemented. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Kawailoa Training Area, Poamoho-Helemano Ridge, Hawaiiloa Ridge, and Halawa Ridge Trail).

3) Maintain adequate genetic stock.

To prevent extinction of *Cyanea koolauensis*, *ex situ* propagation should be initiated. Propagation material should be collected immediately from populations that have only have a few remaining individuals (Kawailoa Training Area, Poamoho-Helemano Ridge, Hawaiiloa Ridge, and Halawa Ridge Trail).

4) Reduce threat from rats.

The threat of rat predation needs to be determined for *Cyanea koolauensis*. If rats are deemed a significant threat, a management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea longiflora Recovery Priority Number 11

Appendix B contains a line drawing of *Cyanea longiflora.*

a. Life History

This species has been observed in flower in February, April, and May and in fruit in August (BISH 424335, 403154, 39634, and 512042). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyanea longiflora usually is found on steep slopes or ridge crests in mesic koa-ohia forest in the Waianae Mountains or wet ohia-uluhe forest in the Koolau Mountains, usually between 620 and 780 meters (2,030 and 2,560 feet) elevation (USFWS 1996b, Lammers 1990). Associated plants in koa-ohia forest include hame, kopiko, uluhe, pilo, and ohia ha. In wet ohia-uluhe forest, associated native plants include akia, alani, hapuu, *Dubautia* sp. (naenae), *Hedyotis* sp. (manono), and *Pittosporum* sp. (hoawa) (USFWS 1996, Lammers 1990).

c. Current and Historic Ranges and Population Status

Cyanea longiflora was known historically from 5 populations in the Waianae Mountains and 6 populations in the Koolau Mountains of Oahu (HHP 1997). Currently 3 populations are known: Pahole Gulch, Makaha Valley, and Makaha-Waianae Kai Ridge in the Waianae Mountains (HHP 1997). The total number of plants in the 3 populations is between 200 and 220. The Pahole Gulch population contains more than 200 individuals, while the remaining two populations contain fewer than 10 individuals (Makaha Valley, Makaha-Waianae Kai Ridge). The populations are on land owned by the City and County of Honolulu and by the State (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Cyanea longiflora* are habitat degradation and/or destruction by feral pigs, fire, potential impacts from military activities, potential predation by rats and slugs, competition with alien plants (strawberry guava, Christmas berry, and prickly Florida blackberry) in the Waianae Mountains and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of individuals remaining in widely-dispersed populations (USFWS 1996b; J. Lau and C. Russell, pers. comms.1997).

e. Conservation Measures

Fencing and removal of feral pigs in the Pahole drainage was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse continues in the surrounding areas. Plants in the Pahole drainage have been measured and mapped, and seeds have been collected from plants outside the fence for nursery cultivation and re-introduction into the fenced areas (T. Takahama, pers. comm. 1997). This species is also being successfully propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Makaha Valley and Makaha-Waianae Kai Ridge). A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Makaha Valley and Makaha-Waianae Kai Ridge).

3) Reduce threat of rat predation.

The 5 populations of *Cyanea longiflora* on Oahu are potentially threatened by rat predation. A management plan to control rats should be developed and implemented. The plan should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Pahole Gulch), City and County of Honolulu, and private lands (Makaha Valley) needs to be developed and implemented.

Cyanea pinnatifida Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea pinnatifida.*

a. Life History

This species has been observed flowering in August (BISH 24360). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyanea pinnatifida typically grows on steep, wet, rocky slopes in diverse mesic forest at an elevation of 490 to 520 meters (1,600 to 1,700 feet) in association with mamaki and ferns (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea pinnatifida* is known from several sites in the central Waianae Mountains. However, many early collections are mixed with a related species, *Cyanea lanceolata* ssp. *calycina,* so the exact number of historical sites is impossible to determine (USFWS 1995, Lammers 1990). Only one individual of this species remains, in Kaluaa Gulch on privately owned land (HHP 1997).

d. Reasons for Decline and Current Threats

The greatest threat is from mortality due to environmental disturbances such as washout, falling rocks and trees. Predation by rats and slugs are also potential threats.

Cyanea pinnatifida is not immediately threatened by alien weeds, and weeding of Koster's curse on the steep slope above the plant could threaten the plant more than the weeds themselves. The plant is not directly threatened by pigs because of its location on the side of a gulch wall, and fencing is not feasible (USFWS 1995).

e. Conservation Measures

Twenty-five individuals have been cloned by DOFAW at the mid-elevation Nike missile site in the Waianae Mountains (B. Garnett, pers. comm. 1997). Two individuals were outplanted in a fenced enclosure in Kaluaa Gulch in May 1996 in Honouliuli Preserve and are being monitored (J. Crummer, pers. comm. 1997). This species is also being propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Conduct surveys.

Surveys are needed of appropriate habitat in historical locations to determine if any other extant populations of this plant exist.

2) Monitor the remaining wild plant for changes in status and threats and implement management actions to protect remaining wild plant, if possible.

Potential management actions include weeding and control of feral pigs, slugs, and rats if they are determined to be threats.

3) Monitor the remaining wild plant for changes in reproductive status.

Collect seeds for *ex-situ* propagation if fruits are produced. Continue cloning if feasible.

4) Enhance wild populations and establish new populations.

Once adequate propagated material is available, and fencing, rat control, and weed control, as appropriate, are underway in the area of the remaining *in situ* population, these populations should be enhanced by outplanting. Establishment of new populations within the historical range of *Cyanea pinnatifida* should be initiated in areas that are managed to minimize the impacts of feral ungulates, rats and alien plants.

Cyanea st.-johnii Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea st.-johnii.*

a. Life History

This species has been observed in flower in July through September (BISH 45930, 45926, 616996, 599686, and 45928). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species typically grows on wet, windswept slopes and ridges from 690 to 850 meters (2,260 to 2,800 feet) elevation in ohia mixed shrubland or ohia-uluhe shrubland (USFWS 1996b). Associated plants include naupaka kuahiwi, uki, kookoolau, kamakahala, naenae, kopiko, hapuu, kanawao, maile, hame, and *Freycinetia arborea* (ieie) (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Cyanea st.-johnii was known historically from 11 populations in the central and southern Koolau Mountains of Oahu (HHP 1997). Currently, between 40 and 50 plants are known from 6 populations — Waimano Trail summit to Aiea Trail summit (fewer than 10 individuals), the summit ridge crest between Manana and Kipapa trails (4 individuals), between the summit of Aiea and Halawa trails (15 individuals), Summit Trail south of Poamoho cabin (1 individual), Wamano ridge between North and North central Waimano (6 individuals), and Wailupe-Waimanalo summit ridge (about 12 individuals). These populations are found on City and County of Honolulu, private, and State lands (HHP 1997).

d. Reasons for Decline and Current Threats

Cyanea st.-johnii is threatened by habitat degradation and/or destruction by feral pigs, potential predation by rats and slugs, competition with weeds (Koster's curse, *Axonopus fissifolius* [narrow leaved carpet grass], *Sacciolepis indica* [glenwood grass]) and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining populations and individuals. The plants between the summit of Aiea and Halawa Trail also are threatened by trampling by hikers (USFWS 1996b; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

No specific conservation measures have been undertaken for *Cyanea st.-johnii.*

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Cyanea st.-johnii* to reduce impacts from feral ungulates. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the remaining extant populations.

3) Maintain adequate genetic stock.

To prevent extinction of *Cyanea st.-johnii, ex situ* propagation should be initiated. Specific efforts should be made to immediately collect propagation material from the remaining extant populations.

4) Reduce threat of rat predation

Populations of this species on Oahu may be seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyanea superba Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea superba*.

a. Life History

The flowering season of *Cyanea superba* varies from year to year depending on precipitation. It ranges from late August to early October. Generally, flowering is at its peak in early to mid-September. Fruits have been known to mature from two to five months, depending on the climatic conditions (Obata and Smith 1981).

b. Habitat Description

Cyanea superba grows in the understory on sloping terrain on a well drained, rocky substrate between 535 and 700 meters (1,760 and 2,200 feet) in elevation (USFWS 1995). Some associated species are *Xylosma hawaiiense* (maua), *Hedyotis terminalis* (manono), and iliahi. The understory is heavily shaded by canopy trees including *Aleurites moluccana* (kukui) and *Pisonia brunoniana* (papala kepau), but is open. The understory is readily invaded by aggressive exotic plants (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea superba* is known from the "Gulches of Makaleha on Mt. Kaala," Waianae Mountains, Oahu. *Cyanea superba* ssp. *regina* was historically present in the southern Koolau Mountains, but has not been collected since 1932 (Wagner *et al.* 1990). After its collection in 1870, there were no further documented sightings of *Cyanea superba* ssp. *superba* until its rediscovery in the Waianae Mountains in 1971. Presently it is known from only one small population on Federal land in Makua Military Reservation, totaling 5 plants. A population of fewer than 5 plants was recently extirpated on State land in Pahole Gulch (K. Kawelo, pers. comm. 1998). A third population, previously reported, appears to be based on a misidentification (USFWS 1995).

d. Reasons for Decline and Current Threats

Some of the greatest immediate threats to the survival of *Cyanea superba* are the degradation of its habitat due to the introduction of alien plants such as strawberry guava and Christmas berry, and predation by rats and slugs. Other major threats are the potential for destruction by wildfires generated in a nearby military firing range. The plants are confined to two small areas of 167 and 56 square meters (1,800 and 600 square feet). The restricted range of this plant makes it vulnerable to even small, local, environmental disturbances and a single incident could destroy a significant percentage of the known individuals. Additionally, the limited gene pool may depress reproductive vigor (USFWS 1995).

e. Conservation Measures

Fencing and removal of feral pigs in the Pahole drainage where the second population was located was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse was conducted in the surrounding areas (T. Takahama, pers. comm. 1997). Forty individuals grown from the Pahole Gulch population of *Cyanea superba* were planted in three different exclosures in Pahole NAR. Seventeen individuals are in the Nike missile mid-elevation facility (B. Garnett, pers. comm. 1997). The Army has plans to outplant 4 individuals in a fenced exclosure in Kahanahaiki on Makua Military Reservation. The wild population on Army land is within a fenced exclosure.

The Army implemented an intensified rat control effort during the 1997 fruiting season (diphacinone bait blocks and snap-trapping) that ensured production and protection of mature fruit.

This species is also being propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the population in Makua Valley.

2) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on Federal land in Makua Valley needs to be developed and implemented.

3) Reduce threat of rat predation

Rat control efforts should be continued. Ultimately a more broad-scale method such as aerial dispersal of rodenticide should be implemented.

4) Relocate and protect *Cyanea superba* var. *regina.*

This variety was last seen in 1932 (HHP 1997). Surveys in appropriate habitat in historical locations should be conducted to determine if there are any other extant populations of this taxon, in order to conserve genetic material (Loyal Mehrhoff, pers. comm. 1997).

Cyanea truncata Recovery Priority Number 5

Appendix B contains a line drawing of *Cyanea truncata.*

a. Life History

This species was observed in flower in December 1919 and November 1980, the last time the species was observed before feral pigs extirpated the population (USFWS 1996a). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyanea truncata typically grows on windward slopes in mesic to wet forests at elevations between 240 and 400 meters (800 and 1,300 feet) (Lammers 1990, USFWS 1996a). Associated plants include *Hibiscus arnottianus* (kokio keokeo), lama, ohia, *Cyrtandra propinqua* (haiwale), *Neraudia melastomifolia* (maaloa), *Pisonia umbellifera* (papala kepau), and *Piper methysticum* (awa) (USFWS 1996a, Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Cyanea truncata* was known from Punaluu, Waikane, and Waiahole in the northern Koolau Mountains of Oahu (USFWS 1996a). One population of at least two individuals was known to exist in "Hidden Valley," a drainage northwest of Kaaawa Valley that terminates at Kaaawa Point in the Koolau Range (USFWS 1996a, Rock 1962); however, that population was destroyed by feral pigs in 1989 (USFWS 1996a). In 1991, John Obata discovered 20 immature lobelioids growing on private land along a gully floor farther upstream from the site of the destroyed *Cyanea truncata* population (USFWS 1996a). This was thought to be the only known population of this species. An individual from this sterile population was salvaged from pig-damaged areas in 1991 and this individual flowered on June 22, 1993. The individual turned out to be *Cyanea crispa* (not *Cyanea truncata*). A site visit in July 1993 determined that all of the plants previously thought to be *Cyanea truncata* were actually *Cyanea crispa*. No individuals of *Cyanea truncata* were located, though it is possible that juvenile plants could be found in the valley floor (L. Mehrhoff, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Cyanea truncata* are habitat degradation and predation by feral pigs, suspected predation by rats and slugs, competition with invasive alien plants (Koster's curse and strawberry guava), and a risk of extinction due to naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals, if any, in fact, remain (USFWS 1996a).

e. Conservation Measures

No specific conservation measures have been undertaken for *Cyanea truncata*.

f. Needed Recovery Actions

1) Conduct surveys.

Surveys of appropriate habitat in historical locations are needed to determine if any other extant populations of this plant exist.

2) Maintain adequate genetic stock.

To prevent extinction of this species, *ex situ* propagation should be initiated immediately if extant individuals are located.

3) Enhance wild populations and establish new populations.

Once adequate propagated material is available, and fencing, rat control, and weed control, as appropriate, are underway in the areas of any remaining *in situ* populations, these populations should be enhanced by outplanting. Establishment of new populations within the historical range of *Cyanea truncata* should be initiated in areas that are managed to minimize the impacts of feral ungulates, rats and alien plants.

Cyrtandra crenata Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species was observed in flower in June 1947 (USFWS 1996a). No other information exists on reproductive cycles, longevity, specific environmental requirements, and limiting factors.

b. Habitat Description

Cyrtandra crenata typically grows in ravines or gulches in mesic to wet forests between elevations of 380 and 730 meters (1,250 and 2,400 feet) with associated plants such as ohia, uluhe, and *Machaerina angustifolia* (uki) (USFWS 1996a, Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Cyrtandra crenata* was known from Waikane Valley along the Waikane-Schofield Trail in the Koolau Mountains (St. John 1966, St. John and Storey 1950, USFWS 1996a). It was last observed below that trail, about 0.8 kilometers (0.5 mile) from its historical location, at the boundary of private and State lands (HHP 1997). This population has not been observed since 1947, and there are no other known individuals.

d. Reasons for Decline and Current Threats

The primary threats to this species are habitat degradation and predation by pigs, suspected predation by rats and slugs, competition with invasive alien plants (Koster's curse and strawberry guava), and a risk of extinction from naturally- occurring events, and/or reduced reproductive vigor due to the species' restricted range and the small number of individuals, if any, in fact, remain (USFWS 1996a).

e. Conservation Measures

No specific conservation measures have been undertaken for *Cyrtandra crenata.*

f. Needed Recovery Actions

1) Conduct surveys.

Surveys of appropriate habitat in historical locations are needed to determine if any other extant populations of this plant exist.

2) Maintain adequate genetic stock.

To prevent extinction of this species, *ex situ* propagation should be initiated immediately if extant individuals are found.

3) Enhance wild populations and establish new populations.

Once adequate propagated material is available, and fencing, rat control, and weed control, as appropriate, are underway in the areas of any remaining *in situ* populations, these populations should be enhanced by outplanting. Establishment of new populations within the historical range of *Cyrtandra crenata* should be initiated in areas that are managed to minimize the impacts of feral ungulates, rats and alien plants.

Cyrtandra dentata Recovery Priority Number 8

Appendix B contains a line drawing of *Cyrtandra dentata.*

a. Life History

This species has been observed in flower and fruit in May and November. No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyrtandra dentata typically grows in gulches, slopes, or ravines in mesic forest with ohia, ohia ha, and kukui at elevations from 580 to 720 meters (1,900 to 2,360 feet) (USFWS 1996b, St. John 1966, Wagner *et al.* 1990). Associated species include papala kepau, mamaki, and alaa.

c. Current and Historic Ranges and Population Status

Cyrtandra dentata was historically known from 6 populations in the Waianae Mountains and 3 populations in the Koolau Mountains of Oahu (HHP 1997). Currently, this species is found only in the Waianae Mountains in Pahole Gulch and Kapuna Valley on State land (within Pahole NAR), Army land at Makua Military reservation in Kahanahaiki Gulch, and in Ekahanui Gulch on private land (within TNCH's Honouliuli Preserve) (HHP 1997). The number of individuals in the 4 known populations is not well documented but the Kahanahaiki population is approximately 50 individuals and the total population probably numbers fewer than 70 individuals.

d. Reasons for Decline and Current Threats

Competition with alien plants (Koster's curse, Christmas berry, and strawberry guava), potential predation by rats and slugs, potential fire, and a risk of extinction from naturally-occurring events (such as landslides/hurricanes/flooding) and/or reduced reproductive vigor, due to the small number of extant populations and individuals, are the major threats to *Cyrtandra dentata* (USFWS 1996b; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

Fencing and removal of feral pigs in the Pahole drainage was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse continues in the surrounding areas. This species is also being propagated at the Lyon Arboretum (G. Koob, pers. comm. 1997).

The Army has adopted a fire management plan which includes realigning targets and establishing firebreaks at Makua Military Reservation. These actions may aid in protecting the two individuals at Kahanahaiki Gulch from the threat of fire. These two plants are currently within a large fenced exclosure from which ungulates have been eradicated (K. Kawelo, pers. comm. 1997).

f. Needed Recovery Actions

1) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect all four populations.

2) Reduce threat of rat predation.

The 3 populations of *Cyrtandra dentata* on Oahu are potentially threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyrtandra polyantha Recovery Priority Number 5

Appendix B contains a line drawing of *Cyrtandra polyantha*.

a. Life History

No information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

A few *Cyrtandra polyantha* are believed to remain on ridges of disturbed mesic valleys in ohia forests at elevations between 490 and 610 meters (1,600 and 2,000 feet) (USFWS 1996a). *Cyrtandra polyantha* probably grows in association with uki, uluhe, hapuu, hame, amau, maile, kanawao, *Coprosma foliosa* (pilo), and kopiko, plants commonly found in the ohia-dominated forests of the Koolau Mountains (USFWS 1996a).

c. Current and Historic Ranges and Population Status

Historically, *Cyrtandra polyantha* was known from the Kalihi region and from Kulepiamoa Ridge above Niu Valley on the leeward (southwest) side of the southern Koolau Mountains (St. John 1966, USFWS 1996a). Two populations, located farther south on Kuliouou summit ridge and at the northwest head of Hahaione Valley (HHP 1997, USFWS 1996a), are believed to be extant and are approximately 1.6 kilometers (1 mile) apart on private and State land. One population (Hahaione Valley) has not been visited within the past 50 years; it is not known how many individuals remain. The most recently observed populations (Kuliouou summit ridge), last seen in 1993, consist of 5 individuals (USFWS 1996a).

d. Reasons for Decline and Current Threats

The primary threats to *Cyrtandra polyantha* are habitat degradation and predation by pigs, suspected predation by rats and slugs, competition from invasive alien plants such as strawberry guava and invasive grasses, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals and their restricted distribution (USFWS 1996a).

e. Conservation Measures

No specific conservation measures have been undertaken for *Cyrtandra polyantha*.

f. Needed Recovery Actions

1) Conduct surveys.

Surveys of appropriate habitat in historical locations are needed to determine if any other extant populations of this plant exist. Hahaione Valley should also be revisited to determine if the population still exists.

2) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the extant populations to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

3) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the extant populations.

4) Maintain adequate genetic stock.

To prevent extinction of *Cyrtandra polyantha*, *ex situ* propagation should be initiated. Specific efforts should be made to immediately collect propagation material from both populations, if feasible.

5) Reduce threat of rat predation.

Cyrtandra polyantha may be seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Cyrtandra subumbellata Recovery Priority Number 8

Appendix B contains a line drawing of *Cyrtandra subumbellata.*

a. Life History

Cyrtandra subumbellata has been observed in fruit in September (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species typically grows on moist, forested slopes or gulch bottoms dominated by ohia or a mixture of ohia and uluhe, between 460 and 670 meters (1,500 and 2,200 feet) elevation (USFWS 1996b). Associated plants include uki, *Boehmeria grandis* (akolea), kanawao, and the ferns, *Thelypteris sandwicensis* and *Tectaria cicutaria* ssp. *gaudichaudii* (HHP 1997; USFWS 1996b; St. John 1966; Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Cyrtandra subumbellata* was known from 6 scattered populations in the central Koolau Mountains on the island of Oahu (HHP 1997). Currently, it is known from 3 populations in the central Koolau Mountains: Schofield-Waikane Trail, Puu Ohulehule (on private and State land), and Kaukonahua drainage (on Federal land in Schofield Barracks Military Reservation) (HHP 1997). The total number of plants is poorly documented, but is estimated to be fewer than 50.

d. Reasons for Decline and Current Threats

The primary threats to *Cyrtandra subumbellata* are competition with the noxious alien plant Koster's curse, potential impacts from military activities, potential predation by rats and slugs, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of extant populations and individuals (HHP 1997; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

The Lyon Arboretum and the National Tropical Botanical Garden are propagating *Cyrtandra subumbellata* (G. Koob and S. Smith, pers. comms.1997).

f. Needed Recovery Actions

1) Control competing alien plant species.

Specific efforts should be made to immediately weed and protect the remaining populations.

2) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Kaukonahua) and private lands (Puu Ohulehule) needs to be developed and implemented.

Cyrtandra viridiflora Recovery Priority Number 5

Appendix B contains a line drawing of *Cyrtandra viridiflora.*

a. Life History

Cyrtandra viridiflora has been observed in fruit and flower from May through September (K. Kawelo, pers. comm. 1998). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Cyrtandra viridiflora is usually found on wind-blown ridge tops in cloud-covered wet forest or shrubland at elevations of 690 to 850 meters (2,260 to 2,800 feet). Associated plants include kanawao, *Trematolobelia macrostachys*, kopiko, manono, *Ilex anomala* (kawau), ohia, ohia ha, alani, naenae, uki, and uluhe (HHP 1997; USFWS 1996b; Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Cyrtandra viridiflora* was known from 7 scattered populations in the Koolau Mountains on the island of Oahu (HHP 1997). Currently, it is known from only 4 populations in the northern Koolau Mountains—Kawainui-Laie summit divide, Kawainui-Kaipapau summit, Maakua-Kaipapau Ridge, and the Peahinaia Trail. The total number of plants known from these 4 populations on State land and private land leased by the DOD for Kawailoa Training Area is approximately 21 (HHP 1997 and K. Kawelo, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The major threats to *Cyrtandra viridiflora* are habitat degradation or destruction by feral pigs, potential impacts from military activities, potential predation by rats and slugs, competition with the alien plants Koster's curse and strawberry guava, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining populations and individuals (USFWS 1996b; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

The Lyon Arboretum is propagating *Cyrtandra viridiflora* (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of *Cyrtandra viridiflora* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed. In locations where fencing is not feasible due to topography or potential damage to sensitive summit habitats, other means of pig control, such as the selective use of snares, should be implemented.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the remaining populations, if feasible.

3) Reduce threat of rat predation.

Populations of *Cyrtandra viridiflora* are seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Delissea subcordata Recovery Priority Number 5

Appendix B contains a line drawing of *Delissea subcordata*.

a. Life History

Fertile plants have been observed in July (K. Kawelo, pers. comm. 1998). An examination of herbarium specimens show that this plant flowers throughout the year (BISH 16220, 45509, 77256, 419101, 92181, 447864, 510124, and 45519). No additional information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Delissea subcordata typically grows on moderate to steep gulch slopes in mesic native or alien-dominated forests from 430 to 760 meters (1,400 to 2,500 feet) elevation (USFWS 1996b). Associated plants include a variety of native plants such as alaa, hame, ohia, manono, maile, *Myrsine lanaiensis* (kolea), *Chamaesyce multiformis* (akoko) papala kepau, *Diospyros hillebrandii* (lama), olopua, and kopiko (HHP 1997 and USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Delissea subcordata* was known from 21 scattered populations in the Waianae Mountains and 8 populations in the Koolau Mountains of Oahu. A specimen collected by Mann and Brigham in the 1860's and labeled as from the island of Kauai is believed to have been mislabeled (HHP 1997). Currently, *Delissea subcordata* is known only from the Waianae Mountains in 18 populations distributed from Kawaiu Gulch (in the Kealia land section in the northern Waianae Mountains) to the northern branch of North Palawai Gulch which is about 20 kilometers (12 miles) to the south. This species is found on private land (TNCH's Honouliuli Preserve), Federal land (Schofield Barracks Military Reservation, Makua Military Reservation and Lualualei Naval Reservation), and State land (Pahole and Kaala NARs) (HHP 1997). The total number of plants in the remaining populations is estimated to be fewer than 80. Only one population numbers at least 10 individuals.

d. Reasons for Decline and Current Threats

Delissea subcordata is threatened by habitat degradation and/or destruction by pigs and goats; potential impacts from military activities, including road construction and housing development; potential predation by rats and slugs; competition with alien plants (Christmas berry, Koster's curse, strawberry guava, and lantana; potential fire; and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals (USFWS 1996b; Takeuchi & Shimabukuro [s.n.][1] 1987; Takeuchi 1985; J. Lau and L. Mehrhoff, pers. comms. 1997).

e. Conservation Measures

Four individuals were outplanted in a fenced enclosure in Kaluaa Gulch in Honouliuli Preserve in November 1994 (J. Crummer, pers. comm. 1997). Three survive, with 2 producing flowers and fruit; however, no recruitment has been observed. The individuals in Palawai Gulch will be included in a fenced exclosure that TNCH plans to construct in 1998 (W. Fulks, pers. comm. 1997). Twenty-six individuals growing in the mid-elevation Nike

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[1] **s.n.** Latin abbreviation indicating that a herbarium specimen lacks a collector's number.

site in the Waianae Mountains were obtained as cuttings from the TNCH Honouliuli preserve in 1997 (B. Garnett, pers. comm. 1997). This species is also being successfully propagated at the Lyon Arboretum, the National Tropical Botanical Garden, and the Waimea Arboretum, In addition, seeds are in storage at the National Tropical Botanical Garden (G. Koob, D. Orr, and S. Smith, pers comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the known populations of this plant to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals should be fenced immediately. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Palikea, Keawapilau, Kapuna, Kaawa, Mohiakea, Pahole, and Kapuhi gulches), if feasible.

3) Reduce threat of rat predation.

Populations of *Delissea subcordata* are seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State Natural Area Reserves (Pahoe and Mt. Kaala), private (Honouliuli) and Federal (Army's Schofield Barracks and Lualualei Naval Reservation) lands needs to be developed and implemented.

Diellia falcata Recovery Priority Number 8

Appendix B contains a line drawing of *Diellia falcata.*

a. Life History

Diellia falcata hybridizes with *Diellia unisora* (J. Lau, pers. comm. 1997). It has been observed with fronds bearing sori (fern spores) year round (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Diellia falcata is a terrestrial fern which typically grows in deep shade or open understory in dryland forest at an elevation of 390 to 820 meters (1,280 to 2,700 feet) (USFWS 1995). Associated plants include aulu, lama, and alaa (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Diellia falcata* was known from almost the entire length of the Waianae Mountains, from Manini Gulch to Palehua Iki, as well as from the Koolau Mountains of Oahu, from Kaipapau Valley to Aiea Gulch (USFWS 1995). This species remains in the Waianae Mountains, from Manini Gulch to Puu Hapapa, Makua Valley and Makaha-Waianai Kai Ridge on Federal, State, and private land (HHP 1997). The 22 known populations, which are found within an area of about 3.2 by 18 kilometers (2 by 11 miles), contain an estimated 5,540–6,540 individuals (HHP 1997). Fourteen populations each number between 40–2,000 individuals; however, 8 populations each number fewer than 10 individuals (Nanakuli-Lualualei Ridge, Makaleha Valley, Puu Kumakalii, Mohiakea Gulch, Pualii Gulch, Puu Kaiwi, Palikea Gulch, Ekahanui Gulch). Recent field observations indicate that this plant may be more locally common than previous records suggest (K. Kawelo, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The major threats to *Diellia falcata* are habitat degradation by feral goats, pigs, and cattle; competition from alien plants (Christmas berry, huehue haole, Koster's curse, molasses grass, strawberry guava, and *Blechnum occidentale*; and fire. The two-spotted leafhopper is a potential threat (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan which includes realigning targets and establishing firebreaks at Makua Military Reservation. These actions may aid in protecting *Diellia falcata* from the threat of fire. Additionally, the Army has protected individuals in Kahanahaiki Gulch from pigs by a fenced enclosure (K. Kawelo, pers. comm. 1997).

Fencing and removal of feral pigs in the Pahole drainage was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse continues in the surrounding areas (T. Takahama, pers. comm. 1997).

Individuals of this plant in the Palawai Gulch will be protected from ungulates by a fenced exclosure that TNCH plans to construct in 1998 (W. Fulks, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Nanakuli-Lualualai Ridge, Makaleha Valley, Puu Kumakalii, Mohiakea Gulch, Pualii Gulch, Puu Kaiwi, Palikea Gulch, Ekahanui Gulch), if feasible. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Nanakuli-Lualualai Ridge, Makaleha Valley, Puu Kumakalii, Mohiakea Gulch, Pualii Gulch, Puu Kaiwi, Palikea Gulch, Ekahanui Gulch), if feasible.

3) Provide protection from fire.

A coordinated fire protection plan needs to be developed and implemented for endangered plants on State Natural Area Reserves (Pahole NAR), private (Honouliuli preserve), and on Federal (Makua Military Reservation) lands.

4) Conduct research into additional limiting factors.

The two-spotted leafhopper is a potential threat to *Diellia falcata*, and should be investigated (J. Lau, pers. comm. 1997).

5) Conduct genetic/taxonomic research

Taxonomic research is needed to determine the taxonomic relationship and genetic distinctiveness of *Diellia falcata* and *Diellia unisora,* and which populations are hybridizing (J. Lau, pers. comm. 1997).

6) Maintain adequate genetic stock

To prevent extinction of this species, *ex situ* propagation should be initiated. Propagation material should be collected immediately from all extant populations.

Diellia unisora Recovery Priority Number 11

No line drawing is available for this species.

a. Life History

Diellia unisora hybridizes with *Diellia falcata* (J. Lau, pers. comm. 1997). Otherwise, little is known about its reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Diellia unisora is a terrestrial fern which typically grows in deep shade or open understory in dryland forest at an elevation of 530 to 760 meters (1,750 to 2,500 feet)

(USFWS 1995). Associated species include koa, ohia, alani, kopiko, kookoolau, akoko, pilo, manono, kawelu, aalii, *Carex meyenii* and *Rumex albescens* (HHP 1997).

c. Current and Historic Ranges and Population Status

Historically, *Diellia unisora* was known from steep, grassy, rocky slopes on the western side of the Waianae Mountains, Oahu (USFWS 1995, Wagner 1952). This species is known to be extant in four areas of the southern Waianae Mountains: South Ekahanui Gulch (6 individuals), Palawai Gulch (90 individuals), Palikea (4 individuals), and the Pualii-Napepeiauolelo Ridge (600 individuals) (HHP 1997; J. Lau, pers. comm. 1997). The 4 known populations, which are on State and privately owned land, are scattered over a distance of about 3.2 kilometers (2 miles), and contain approximately 700 individuals (HHP 1997; J. Lau, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threat to *Diellia unisora* is competition from alien plants (Christmas berry, molasses grass, huehue haole, strawberry guava, and *Blechnum occidentale*), habitat degradation by feral pigs, potential threat from the two-spotted leafhopper, and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals (USFWS 1995).

e. Conservation Measures

No specific conservation measures have been undertaken for *Diellia unisora.*

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of *Diellia unisora* to reduce impacts from feral pigs. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (South Ekahanui Gulch and Palikea). A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (South Ekahanui Gulch and Palikea).

3) Maintain adequate genetic stock.

To prevent extinction of this species, *ex situ* propagation should be initiated. Propagation material should be collected immediately from all extant populations.

4) Conduct research into additional limiting factors.

The two-spotted leafhopper is a potential threat to *Diellia unisora*, and should be investigated (J. Lau, pers. comm. 1997).

5) Conduct genetic/taxonomic research.

Taxonomic research is needed to determine the taxonomic relationship and genetic distinctiveness of *Diellia falcata* and *Diellia unisora,* and determine which populations are hybridizing (J. Lau, pers. comm. 1997).

Dubautia herbstobatae Recovery Priority Number 8

No line drawing is available for this species.

a. Life History

Dubautia herbstobatae is likely out-crossing and possibly self-incompatible (i.e., pollen from the same plant will not produce seed). Flowering usually occurs in May and June. Pollination is almost certainly achieved by insect activity and fruit dispersal is probably quite localized (Carr 1982).

b. Habitat Description

Dubautia herbstobatae typically grows on rock outcrops on north-facing ridges in dry shrubland at an elevation of 580 to 910 meters (1,900 to 3,000 feet) (USFWS 1995). Associated plants include ohia, *Carex meyenii, Artemisia Australia* (ahinahina), *Lysimachia hillebrandii* (kolokolo kuahiwi), *Chamaesyce multiformis* (akoko), and kawelu (USFWS 1995).

c. Current and Historic Ranges and Population Status

Dubautia herbstobatae is known to be extant in the northern Waianae Mountains, on Makua-Keaau (500 individuals), Waianae Kai (4 individuals) and Kamaileunu ridges (1 individual), and Keaau Valley (20 individuals) on Federal, State, and City/County land (HHP 1997). No other locations are known for this recently-discovered species (Carr 1979, 1982). The 4 known populations, which are scattered over an area of about 1.6 by 5 kilometers (1 by 3 miles), contain approximately 525 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Dubautia herbstobatae* are habitat degradation by feral goats, competition from alien plants (daisy fleabane, Christmas berry, koa haole, and molasses grass), fire, military activities, and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals, and visitation and possible trampling by humans (USFWS 1995). Pigs may pose only a minor threat to this plant due to its cliff habitat.

e. Conservation Measures

The Army is constructing a fence along Ohikilolo Ridge and the eastern rim of Makua Valley. The fence will provide a barrier to goats and pigs beginning at the central ridge of Makua, following the valley perimeter to the south west, and ending at Farrington Highway. This fence should help to prevent further goat ingress into Makua from the neighboring Keaau Ranch. The Army contracts goat control in the valley to Wildlife Services staff of the U.S. Department of Agriculture. Their success is limited by steep terrain and limited access because of dangerous unexploded ordnance. Army staff are also beginning in-house goat control. The above actions should benefit the populations of *Dubautia herbstobatae* that occur within Makua Valley (K. Kawelo, pers. comm. 1997). The National Tropical Botanical Garden has seeds of this species (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct strategic fencing to protect populations from feral ungulates.

Due to the cliff habitat of these plants, exclosures, though preferred, are not necessarily feasible. In such locations, strategic barrier fences may be constructed to restrict goat access. Such measures should be taken to protect populations that are not currently being managed for ungulates and that have only a few remaining individuals (Waianae Kai, Kamaileunu Ridge, and Keaau Valley).

Control or removal of goats from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been fenced.

2) Control competing alien plant species in enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Waianae Kai, Kamaileunu Ridge, and Keaau Valley), where accessible.

3) Maintain adequate genetic stock.

To prevent extinction of *Dubautia herbstobatae*, *ex situ* propagation should be initiated. Propagation material from all extant populations should be collected immediately.

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Waianae Kai) and Federal (Makua Military Reservation) lands needs to be developed and implemented.

Eragrostis fosbergii Recovery Priority Number 5

Appendix B contains a line drawing of *Eragrostis fosbergii*.

a. Life History

No information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Eragrostis fosbergii typically grows on ridge crests or moderate slopes in native or alien forests between 720 and 830 meters (2,360 and 2,720 feet) elevation (USFWS 1996b). Associated plants include koa, ohia, alahee, aalii, and *Eragrostis grandis* (kawelu) (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Eragrostis fosbergii* was known only from the Waianae Mountains of Oahu, from the slopes of Mount Kaala and in Waianae Kai and its associated ridges (HHP 1997). It was thought to be extinct until rediscovered by Joel Lau of TNCH in 1991. Only 6 individuals are known to remain in Waianae Kai, in 4 populations on land owned by the City and County of Honolulu (HHP 1997).

d. Reasons for Decline and Current Threats

Major threats to *Eragrostis fosbergii* include degradation of habitat by feral pigs and goats; competition from alien plants such as Christmas berry, silk oak, and strawberry guava; fire; and trampling by hikers. This species also is threatened by the risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining populations and individuals (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

In 1996–97, staff from DOFAW and TNCH conducted surveys in the Waianae Kai area, but they located no individuals of this plant (B. Garnett, pers. comm. 1997). It is difficult to identify in the field because flowers are needed to confirm its identity.

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the remaining known populations of *Eragrostis fosbergii* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the remaining populations.

3) Maintain adequate genetic stock.

To prevent extinction of *Eragrostis fosbergii, ex situ* propagation should be initiated. Specific efforts should be made to immediately collect propagation material from the remaining populations, if feasible.

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State and City and County of Honolulu lands needs to be developed and implemented.

Eugenia koolauensis Recovery Priority Number 5

Appendix B contains a line drawing of *Eugenia koolauensis*.

a. Life History

This species has been observed in flower from February to December in various years (USFWS 1996a). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Eugenia koolauensis exists in dry gulches and ridges in mesic forests dominated by ohia and/or lama at 100 to 300 meters (350 to 1,000 feet) in elevation (USFWS 1996a, Wagner *et al.* 1990). Other associated plants include *Myrsine lessertiana* (kolea lau nui), olopua, *Pittosporum glabrum* (hoawa), alaa, *Pleomele halapepe* (halapepe), alahee, and *Rauvolfia sandwicensis* (hao) (USFWS 1996a).

c. Current and Historic Ranges and Population Status

Eugenia koolauensis was historically known from Maunaloa on western Molokai and from Kaipapau Valley, Hanaimoa and Kahawainui gulches, and a gully southeast of Kahuku on Oahu (USFWS 1996a, Wilson 1957). This species is no longer believed to be extant on the island of Molokai, because the region where the first two individuals were found was converted to pineapple fields (USFWS 1996a). On Oahu, 8 populations now remain with 6 in the northern Koolau Mountains and 2 in the southern Koolau Mountains. In the northern Koolaus, 1 population occurs on State land in Papali Gulch and 2 populations occur at Pupukea-Paumalu in Kaleleiki and Aimuu Gulch. This plant also occurs on private land leased to the Army for Kahuku Training Area at Kaunala Gulch, Pahipahialua Gulch, and Oio Gulch. The two disjunct populations in the southeastern Koolau Mountains occur at Hawaii Loa and Aina Haina (HHP 1997, USFWS 1996a). A total of fewer than 220 individuals remain. Four populations contain between 32–80 individuals; the 4 remaining populations each contain fewer than 15 individuals (Papali Gulch, Kaunala Gulch, Wailupe Gulch, and Hawaii Loa Ridge).

d. Reasons for Decline and Current Threats

Habitat degradation by feral pigs, trampling by humans, and competition with alien plants (Christmas berry, Koster's curse, shoebutton ardisia, strawberry guava, and lantana), and close proximity to motor bike trails are the major threats to *Eugenia koolauensis* (USFWS 1996a). The limited numbers of this species make it vulnerable to extinction due to naturally-occurring events and/or reduced reproductive vigor due to the small number of individuals and limited gene pool (USFWS 1996a).

e. Conservation Measures

The Army is controlling shoebutton ardisia near the *Eugenia koolauensis* population in Kahuku Training Area. The Army has also attempted to reroute mountain bike trails away from the population.

Eugenia koolauensis has been successfully propagated at the Waimea Arboretum (D. Orr, pers. comm. 1997). The Lyon Arboretum has attempted propagation, but has had no success (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Eugenia koolauensis* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Papali Gulch, Aimuu Gulch, Wailupe Gulch, Hawaii Loa Ridge), if feasible. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Papali Gulch, Aimuu Gulch, Wailupe Gulch, Hawaii Loa Ridge), if feasible.

Gardenia mannii Recovery Priority Number 5

Appendix B contains a line drawing of *Gardenia mannii.*

a. Life History

Gardenia mannii has been observed in flower and fruit in June and September (K. Kawelo, pers. comm. 1998). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species is usually found on moderate to moderately steep gulch slopes between 300 and 750 meters (980 and 2,460 feet) in elevation (USFWS 1996b). Ohia co-dominates in mesic or wet forests with a mixture of native plants such as alaa, koa, and uluhe. Other associated plants include kalia, *Diplazium sandwichianum* (hoio), alani, hoawa, *Tetraplasandra oahuensis* (ohe mauka), hame, kanawao, pilo, kawau, *Alyxia oliviformis* (maile), and kopiko (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically *Gardenia mannii* was known from 7 widely scattered populations in the Waianae Mountains and 39 populations distributed along almost the entire length of the Koolau Mountains of Oahu (HHP 1997). Currently 23 populations of *Gardenia mannii* are distributed along a 42-kilometer (26-mile) length of the Koolau Mountains, from Kaunala Gulch and Kaunala-Waimea Ridge at the northernmost extent of its range to Palolo at the southernmost extent (HHP 1997). In the Waianae Mountains, this species is found in 5 extant populations over a 7-kilometer (4-mile) distance from north Haleauau Valley to Kaluaa Gulch (HHP 1997). The 28 extant populations occur on private land, including TNCH's Honouliuli Preserve and land leased by DOD for Kawailoa and Kahuku Training Areas; City and County of Honolulu land; State land; and Federal land on Schofield Barracks Military Reservation.

The existing populations total between 70 and 100 individuals, with 23 of the 27 populations each containing 5 or fewer individuals.

d. Reasons for Decline and Current Threats

Gardenia mannii is threatened by habitat degradation and/or destruction by feral pigs; potential impacts from military activities; competition with alien plants such as Koster's curse, prickly Florida blackberry, and strawberry guava; potential fire; and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the widely dispersed, small number of remaining individuals. This species is also potentially threatened by predation from rats. The Kapakahi Gulch population also is threatened by the black twig borer (USFWS 1996b; L. Mehrhoff, pers. comm. 1997).

e. Conservation Measures

Because of the impossibility of hunting due to dangers associated with unexploded ordnance, the Army is experimenting with leg snaring to control pig populations in areas adjacent to *Gardenia mannii* individuals in Schofield Barracks Military Reservation, West Range (K. Kawelo, pers. comm. 1997).

The Lyon Arboretum and the National Tropical Botanical Garden have successfully propagated *Gardenia mannii,* and seeds are in storage at the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Gardenia mannii* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Additionally, specific efforts should be made to immediately fence and protect the 23 populations that have only a few remaining individuals. A commitment should be developed for long-term stewardship and conservation of all of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals.

3) Implement promising control methods for the black twig borer suggested by further research.

The black twig borer has been identified as a threat to one population of *Gardenia mannii*. It is not known how this plant will be affected by defoliation or reduced vigor due to infestations of this alien insect. A number of parasitoids have been introduced to control the beetle, though none of them have become established. Further research on biological control of the beetle will need to proceed cautiously as a number of rare native Hawaiian scolytids are closely related to the black twig borer (P. Conant, pers. comm. 1997; J. Nakatani, *in litt.* 1996).

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on City and County of Honolulu, Federal (Schofield Barracks Military Reservation), and private (Honouliuli, Kawailoa and Kahuku Training Area) lands needs to be developed and implemented.

5) Reduce threat of rat predation.

Populations of this species are seriously threatened by rat predation. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Gouania meyenii Recovery Priority Number 5

Appendix B contains a line drawing of *Gouania meyenii.*

a. Life History

Gouania meyenii flowers from March to May. Seed capsules develop in about 6 to 8 weeks. Plants appear to live about 10 to 18 years in the wild (USFWS 1995). No other information exists on specific environmental requirements or limiting factors.

b. Habitat Description

Gouania meyenii typically grows on rocky ledges, cliff faces, and ridge tops in dry shrubland or ohia lowland mesic forest at an elevation of 580 to 820 meters (1,900 to 2,700 feet) (USFWS 1995). Associated plants include aalii, akoko, kopiko, manono, alani, olopua, kookoolau, *Carex meyenii*, lama, kolokolo kuahiwi, and *Senna gaudichaudii* (kolomona) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Gouania meyenii* was known from central and southern areas of the Waianae Mountains, from Kamaileunu Ridge to Honouliuli (USFWS 1995, Wagner *et al.* 1990). This species was also recorded from Diamond Head in 1831 (HHP 1997). Currently, on Oahu, this species is found on Kamaileunu Ridge and Makaha-Waianae Kai Ridge on State and City/County land (HHP 1997; J. Lau, pers. comm. 1997). This species was recently discovered on Kauai, in two locations in the Na Pali-Kona Forest Reserve and one location in Koaie Canyon (HHP 1997). The 4 known populations on Oahu, which are in an area of about 2.6 square kilometers (1 square mile), contain an estimated 83 individuals (HHP 1997). The 3 populations on Kauai, 1 in Hipalau Valley (Koaie Canyon) and 2 in Kalalau Valley (Na Pali-Kona Forest Reserve) are within approximately 9.6 kilometers (4 miles) of each other (HHP 1997) and contain an estimated 9 individuals. The total population on both islands is estimated to be 92 individuals with 7 populations.

d. Reasons for Decline and Current Threats

The major threats to *Gouania meyenii* are competition from alien plants (Christmas berry, molasses grass, and strawberry guava), fire, habitat degradation by feral pigs and goats, and the small number of extant populations (USFWS 1995).

e. Conservation Measures

This species is being propagated at the National Tropical Botanical Garden and the Lyon arboretum (S. Smith and Greg Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the known populations of *Gouania meyenii* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals, such as within the Waianae Kai Forest Reserve on Oahu and those in the Na Pali-Kona Forest Reserve on Kauai. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals should be immediately weeded and protected.

3) Provide protection from fire.

A coordinated fire protection plan needs to be developed for endangered plant species on State forest reserves (Waianae Kai on Oahu and Na Pali-Kona on Kauai) and Federal lands.

Gouania vitifolia Recovery Priority Number 5

Appendix B contains a line drawing of *Gouania vitifolia.*

a. Life History

In winter and spring the main vine of *Gouania vitifolia* produces new young side shoots which soon die. Plants have been observed flowering from late November to January, but flowering probably depends on precipitation (USFWS 1995).

Although plants have been observed flowering, *Gouania vitifolia* has never been observed fruiting and it is unknown whether the flowers are perfect (i.e., produce both pollen and ovules).

b. Habitat Description

Information is scant, but data from herbarium labels indicate that *Gouania vitifolia* prefers dry, rocky ridges and slopes in dry shrubland or dry to mesic forests at an elevation of about 610 meters (2,000 feet). Associated plants include olopua and mamaki (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Gouania vitifolia* was known from West Maui; the Kau District of the island of Hawaii; and the northwestern portion of the Waianae Mountains in Makaleha, Keaau, and Waianae Kai valleys (USFWS 1995, St. John 1969, Wagner *et al.* 1990). However, it is currently known on Oahu from only a single population of 8 individuals, which was discovered in 1990 on the slopes of Waianae Kai Ridge on State-owned land on Oahu (HHP 1997). The 8 plants are close to one another, growing in two patches in a forest of mostly naturalized, non-native plants (HHP 1997), and may represent clones of a single individual (USFWS 1995). Two additional populations, totaling 18 individuals, were recently discovered on Hawaii within the Manuka Natural Area Reserve (B. Stevens, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The major threats to *Gouania vitifolia* on Oahu are competition from alien plants such as huehue haole, strawberry guava, and Christmas berry and fire. On Hawaii this plant is threatened by common guava, sweet granadilla (*Passiflora ligularis*), and banana poka. All populations are threatened by habitat destruction by feral pigs, and could suffer extinction and/or reduced reproductive vigor due to the small number of extant individuals, all of which may be genetically identical (USFWS 1995).

e. Conservation Measures

Asexual propagation (via cuttings) and weeding was conducted in the area of the single population by DOFAW during February 1997 (B. Garnett, pers. comm. 1997). This species is also being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997)

One of the Big Island populations is located at Olopua kipuka which is slated for fencing. Individuals from the Big Island populations are in propagation at the Volcano Plant Facility (B. Stevens, pers. comm. 1998).

f. <u>Needed Recovery Actions</u>

1) Construct enclosure to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Gouania vitifolia* to reduce impacts from feral pigs. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the remaining populations. It may be possible to carefully weed competing alien vines such as lilikoi (*Passiflora edulis*) from around remaining plants, but alien trees that support *Gouania vitifolia* should be left in place (J. Lau, pers. comm. 1997).

Hedyotis degeneri Recovery Priority Number 5

No line drawings are available for this species.

a. <u>Life History</u>

This species has been observed in flower in November, June, and July, and in fruit in July (BISH 632338, 637275, and 63177). No further information is available on flowering cycle, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Hedyotis degeneri typically grows in diverse mesic forest at an elevation of 820 meters (2,700 feet) (USFWS 1995). Associated plants include ohia, akoko, kolokolo kuahiwi, *Stenogyne kaalae, Psychotria hathewayi* (kopiko), and *Hedyotis terminalis* (manono) (USFWS 1995 and BISH herbarium specimens).

c. Current and Historic Ranges and Population Status

Historically, *Hedyotis degeneri* is known from Mt. Kaala in the northern Waianae Mountains (Wagner *et al.* 1990). Currently, it is known from 3 populations consisting of 6 individuals on Kamaileunu Ridge, 25 individuals near Pahole Gulch, and 1 individual in Makaleha Valley totaling 32 individuals (HHP 1997; J. Lau, pers. comm. 1997). All of these populations occur on State-owned land.

d. Reasons for Decline and Current Threats

The major threats to *Hedyotis degeneri* are habitat destruction by feral pigs, competition from alien plants (Christmas berry, molasses grass, and strawberry guava), and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

This species is being successfully propagated at the National Tropical Botanical Garden and the Lyon Arboretum (S. Smith and G. Koob pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Hedyotis degeneri* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect the extremely small populations at Kamaileunu Ridge and

Makaleha Valley. A commitment should be developed for long-term stewardship and conservation of all of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

The remaining populations should immediately be weeded and protected.

3) Conduct surveys to locate *Hedyotis degeneri* var. *coprosmifolia.*

If located, genetic material should be collected, the remaining individuals protected via fencing, weeding, etc., and research undertaken to determine whether this truly represents a genetically distinct variety (J. Lau, pers. comm. 1997). Surveys should be conducted in the areas where *Hedyotis degeneri* is found.

Hedyotis parvula Recovery Priority Number 5

No line drawings are available for this species.

a. Life History

Hedyotis parvula has been observed flowering in both winter and summer. The plant is found in dry areas and flowering may be induced by rain (USFWS 1995).

b. Habitat Description

Hedyotis parvula typically grows on and at the bases of cliff faces, rock outcrops, and ledges in dry habitat at an elevation of 720 to 830 meters (2,350 to 2,730 feet) (USFWS 1995). Associated plants include aalii, alahee, and *Plectranthus parviflorus* (alaala wai nui) (USFWS 1995, Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Hedyotis parvula* was known from the central and southern Waianae Mountains, from Makaleha Valley to Nanakuli Valley (Wagner *et al.* 1990). This species grew on Makaleha Ridge in 1986 and on Makua-Keaau Ridge in 1976, on State and

Federally owned land (USFWS 1995; J. Lau, pers. comm. 1997). It is now known from 4 populations, all on Federally-owned land. Two of these populations occur on Makua Military Reservation (150 individuals total), one population on Palikea Ridge between Nanakuli and Lualualei (60–75 individuals), and one population west of Palawai Gulch (10 individuals) totaling 220–235 individuals (HHP 1997; J. Lau, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Hedyotis parvula* are habitat degradation by feral goats and pigs, fire, military activities, competition from alien plants (Christmas berry, daisy fleabane, Maui pamakani, and molasses grass), and the small population size (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. Implementation of the plan may aid in protecting this species from fire. Completion of a boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should help to protect this species from further goat damage (K. Kawelo, pers. comm. 1997).

The National Tropical Botanical Garden and Lyon Arboretum are propagating this species (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures or other strategic fencing to protect populations against feral ungulates.

Where feasible, enclosures should be constructed around the known populations of *Hedyotis parvula* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect the population west of Palawai Gulch. Strategic fencing of the Palikea Ridge population should also be considered because it would prevent pigs from degrading the area and reaching accessible parts of the population. Strategic fencing would also prevent goats from moving up the ridge. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (west of Palawai Gulch) should be weeded and protected immediately, where accessible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State and Federal lands needs to be developed and implemented.

Hesperomannia arborescens Recovery Priority Number 5

Appendix B contains a line drawing of *Hesperomannia arborescens*.

a. Life History

This species was observed in flower from April through June (K. Kawelo, pers. comm. 1998) and fruit during March 1993 (USFWS 1996a) and June 1997 (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, and limiting factors.

b. Habitat Description

Hesperomannia arborescens, often found on slopes or ridges in association with akia, ohia, olopua, uluhe, hame, kopiko, ohia ha, manono, and common *Melicope* species (alani), typically grows in lowland wet forests and occasionally in scrub vegetation between 360 and 750 meters (1,200 and 2,500 feet) in elevation (USFWS 1996b Wagner *et al.* 1990). The Molokai population grows in lama and/or ohia-dominated lowland mesic forest habitat within the same elevational range (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Hesperomannia arborescens was formerly known from locations on three islands: Kaiholena and Kukui on Lanai; Pelekunu Trail on Molokai; and scattered populations throughout the Koolau Mountains of Oahu, from Koolauloa and Pupukea at its northern extreme to Konahuanui at the southern end (Forbes 1920, USFWS 1996b). Currently, this species is known from 15 populations totaling fewer than 100 individuals on the islands of Oahu, Molokai, and Maui.

On Oahu, 13 populations, which total about 80 individuals, have been observed since 1970 on private, State, and Federal lands at a few disjunct locations over a distance of about 43 kilometers (27 miles) in the Koolau Mountains. Populations are located at Poamoho summit and stream, Waimanalo-Nui divide, North Halawa-South Halawa Ridge, ridge between Ohia ai-Oio Gulches, Laie-Waimea ridge, North and South Kaukonahua drainages, and Maakua-Kaipapau divide, Kapakahi Gulch, Lanipo summit, Opaeula stream, and Schofield Waikane (HHP 1997; K. Kawelo, pers. comm.).

On Molokai, one population of 3 individuals was found on State land in Olokui Natural Area Reserve (USFWS 1996b). A discovery in 1989 by Joel Lau of The Nature Conservancy of Hawaii extends this species' range to the island of Maui, where he discovered two colonies, comprising a single population totaling 4 individuals about 0.5 kilometer (0.3 mile) apart on State land in West Maui NAR between Lanilili and Keahikauo (USFWS 1996b).

d. Reasons for Decline and Current Threats

The major threats to *Hesperomannia arborescens* are habitat degradation by feral pigs and goats, competition with alien plants (Hilo grass, Koster's curse, strawberry guava, *Tibouchina herbacea*), fire, and impact by humans (USFWS 1996a). Extinction and/or reduced reproductive vigor due to this species' limited numbers are significant threats as well. The single population on Maui is in an area that is subject to heavy pig damage, which is directly threatening the survival of these plants (Bob Hobdy, DOFAW, pers. comm. 1997).

e. Conservation Measures

The State of Hawaii has attempted propagation of this species with no success. They also conduct periodic weed removal at the Laie population (USFWS 1996b). In addition, Maui Division of Forestry and Wildlife intends to fence the 4 individuals in West Maui to protect them from pigs (B. Hobdy, pers. comm. 1997).

The National Tropical Botanical Garden and the Lyon Arboretum are propagating *Hesperomannia arborescens* (S. Smith and G. Koob, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around all known populations of *Hesperomannia arborescens* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals should immediately be weeded and protected (i.e., Wailua-Waiehu Ridge on Molokai, Lanilili and Keahikauo valleys on Maui, and several sites on Oahu).

Hesperomannia arbuscula Recovery Priority Number 5

Appendix B contains a line drawing of *Hesperomannia arbuscula*.

a. Life History

Hesperomannia arbuscula usually flowers in the spring depending on precipitation. Seeds mature in about six weeks and trees last about 10 to 15 years (USFWS 1995).

b. Habitat Description

Hesperomannia arbuscula typically grows on slopes and ridges in mesic to wet forest dominated by koa and ohia at an elevation of 350 to 900 meters (1,200 to 3,000 feet) (USFWS 1995, Wagner *et al.* 1990). Associated plants include *Rumex albescens*, *Diospyros* *hillebrandii* (lama), *Myrsine lessertiana* (kolea lau nui) mamaki, ahakea, ohia ha, kookoolau, maile, and kopiko (HHP 1997; USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Hesperomannia arbuscula* is known from the central and southern Waianae Mountains, from Makaleha to Puu Kanehoa, and from West Maui (USFWS 1995). Currently, this species is known to be extant on State and private land on the Makaha-Waianae Kai Ridge (2 populations, about 50 and 20 individuals, respectively), and in Kaluaa (5–7 individuals) and Kapuna gulches (13 individuals) on Oahu; and Iao Valley (1 individual) on West Maui (HHP 1997; J. Lau, pers. comm. 1997). The 4 known populations consisting of approximately 90 plants on Oahu are within an area of about 3 by 8 kilometers (2 by 5 miles). Including the fifth population from West Maui, this species numbers about 90 individuals (HHP1997; J. Lau, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Hesperomannia arbuscula* are habitat degradation by feral pigs, competition from alien plants (prickly Florida blackberry, Christmas berry, Koster's curse, and strawberry guava), trampling or collection by humans, and the small number of populations (USFWS 1995). *Hesperomannia arbuscula* seeds are often empty and do not appear to develop fully. (J. Lau, pers. comm. 1997).

e. Conservation Measures

DOFAW has weeded the Pahole NAR population and removed Koster's curse and Christmas berry (T. Takahama, pers. comm. 1997). They also have plans to outplant this species at one of the Pahole NAR outplanting exclosures (B. Garnett, pers. comm. 1997). This species is being propagated at the National Tropical Botanical Garden and the Lyon Arboretum (S. Smith and G. Koob, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations, in particular those that have only a few remaining individuals (i.e., Kaluaa and Kapuna gulches on Oahu and Iao Valley on Maui), to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Once these areas are enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Kaluaa and Kapuna gulches on Oahu and Iao Valley on Maui), should immediately be weeded and protected, as feasible.

3) Conduct research on limiting factors, especially reproductive biology and pollination.

Hesperomannia arbuscula seeds are often empty and do not appear to develop fully. The reasons for this need to be investigated (J. Lau, pers. comm. 1997).

Labordia cyrtandrae Recovery Priority Number 5

Appendix B contains a line drawing of *Labordia cyrtandrae*.

a. Life History

Labordia cyrtandrae has been observed flowering from May through June and fruiting from July through August and is sporadically fertile year round (K. Kawelo, pers. comm. 1997). The flowers are functionally unisexual and male and female flowers are on separate plants. No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Labordia cyrtandrae typically grows in shady gulches in mesic to wet forests dominated by ohia, uluhe lau nui, and/or koa between the elevations of 730 and 780 meters

(2,400 and 2,560 feet) (USFWS 1996b). Associated plants include alaa, hoio, mamaki, *Perrottetia* sp. (olomea), kanawao, haiwale, pilo, and kopiko (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Labordia cyrtandrae* was known from both the Waianae and Koolau Mountains of Oahu. In the Koolau Mountains, this species ranged from Kawailoa Trail to Waialae Iki, extending almost the entire length of the mountain range (HHP 1997). Currently, 5 populations totaling 13 individuals are extant. In the Waianaes, this species is known from 2 populations and 4 individuals at Haleauau Gulch, one population of 4 individuals at Mt. Kaala, and 1 individual located in the gulch between Mokiahea and Haleauau gulches, Waianae Mountains. These 4 populations occur on Federal land in Schofield Barracks Military Reservation (HHP 1997; K. Kawelo, pers. comm. 1998). One additional population containing 2 individuals was discovered in 1997 on the ridge between Kaalaea and Waihee near the Kahana summit in the Koolau Mountains (K. Wood, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The primary threats to *Labordia cyrtandrae* are habitat degradation and/or destruction by feral pigs; potential impacts from military activities; rats; competition with the alien plants Christmas berry, Koster's curse, prickly Florida blackberry, and strawberry guava; potential fire; and risk of extinction from naturally-occurring events and/or reduced reproductive vigor, due to the small number of remaining individuals and populations (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

The Army has constructed a small fence around one individual of *Labordia cyrtandrae* in Schofield Barracks West Range. This fence protects the individual from both pigs and falling rocks (K. Kawelo, pers. comm. 1997). The Army has also hand pollinated individuals of this species occurring on Schofield Barracks Military Reservation.

The Lyon Arboretum's efforts at propagating *Labordia cyrtandrae* have been unsuccessful (G. Koob, pers. comm. 1997).

f. <u>Needed Recovery Actions</u>

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the remaining populations of *Labordia cyrtandrae* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed. If fencing is deemed not feasible, other methods of ungulate control, including snaring, are recommended.

2) Control competing alien plant species within enclosures.

The remaining populations should immediately be weeded and protected, if feasible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on Federal land needs to be developed and implemented.

4) Reduce threat of rat predation.

Populations of *Labordia cyrtandrae* are seriously threatened by rat predation. A rat control plan should be developed and implemented to control rats during fruiting season. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

5) Maintain adequate genetic stock.

To prevent extinction of *Labordia cyrtandrae*, *ex situ* propagation should be initiated. Propagation material should be collected immediately from the remaining populations. To date, *ex situ* propagation has not been successful. More research must be conducted to determine a successful method of *ex situ* propagation.

Lepidium arbuscula Recovery Priority Number 8

Appendix B contains a line drawing of *Lepidium arbuscula*.

a. Life History

This species has been observed in flower in February (R. Fenstenmacher, pers. comm. 1998). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Lepidium arbuscula generally grows on exposed ridge tops and cliff faces in mesic vegetation communities between 230 and 915 meters (755 and 3,000 feet) elevation. This species is typically associated aalii, *Rumex albescens*, ilima, alahee, kawelu, kookoolau, hinahina, kolokolo kuahiwi, and *Carex* spp. (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Lepidium arbuscula* was known from 11 populations in the Waianae Mountains (USFWS 1996b). It now remains at 10 populations on Federal (Lualualei Naval Reservation, Makua Military Reservation, and Schofield Barracks Military Reservation), State, and City and County of Honolulu land. Populations range from Kuaokala in the northern Waianae Mountains to Lualualei-Nanakuli Ridge in the southern Waianae Mountains (HHP 1997). Fewer than 900 individuals of this species remain. Three populations number between 100–600 individuals; however, 3 populations number fewer than 10 individuals (Manini Gulch and Mohiakea Gulch).

d. Reasons for Decline and Current Threats

The primary threats to *Lepidium arbuscula* are habitat degradation and/or destruction by feral goats; potential impacts from military activities; competition with alien plants (including Christmas berry, lantana, Maui pamakani, molasses grass, silk oak, strawberry guava, Hamakua pamakani, and firetree); and potential fire (USFWS 1996b). The population at the head of Kapuhi Gulch also is threatened by its proximity to a road (HHP 1997).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. Implementation of the plan may aid in protecting this species from fire. Completion of a boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should help to protect the Makua-Keaau ridge plant from further goat damage (K. Kawelo, pers. comm. 1997).

This species is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic fencing to protect populations against feral goats.

Where feasible, enclosures or strategic barrier fences should be constructed around the known populations of *Lepidium arbuscula* to reduce impacts from feral goats. Control or removal of goats from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (Manini Gulch, Mohiakea Gulch) should immediately be fenced if feasible, or otherwise protected from ungulates. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Where accessible, populations that have only a few remaining individuals (Manini Gulch, Mohiakea Gulch) should immediately be weeded and protected.

Lipochaeta lobata* var. *leptophylla Recovery Priority Number 6

No line drawing is available for this taxon.

a. Life History

Flowering of *Lipochaeta lobata* var. *leptophylla* is probably rain-induced. Populations may consist of fewer distinct individuals than it appears because many "individuals" are connected underground by the roots and are probably clones (USFWS 1995).

b. Habitat Description

Lipochaeta lobata var. *leptophylla* typically grows in dry shrubland at an elevation of 460 to 760 meters (1,500 to 2,500 feet) (USFWS 1995). Associated plants include aalii, alaala wai nui, and kookoolau (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Lipochaeta lobata* var. *leptophylla* was known from the southern Waianae Mountains, from Kolekole Pass to Lualualei (Wagner *et al.* 1990). This taxon remains on Lualualei-Nanakuli Ridge (2 individuals), Puu Hapapa (100 individuals), and Puu Kaua (40 individuals) on Federal land (HHP 1997). The 3 known populations, which are about 6.7 kilometers (4.2 miles) apart, contain about 142 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Lipochaeta lobata* var. *leptophylla* are competition from alien plants (Christmas berry, koa haole, and molasses grass), feral goats, fire, and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

The National Tropical Botanical Garden and Lyon Arboretum are propagating this species (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral goats.

Enclosures should be constructed around the known populations of *Lipochaeta lobata* var. *leptophylla* to reduce impacts from feral goats. Subsequent control or removal of goats from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (Lualualei-Nanakuli Ridge) should be fenced and protected immediately. Once these populations are enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Lualualei-Nanakuli Ridge) should immediately be weeded and protected.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on Federal (Lualualei) lands and adjacent lands needs to be developed and implemented.

Lipochaeta tenuifolia Recovery Priority Number 8

Appendix B contains a line drawing of *Lipochaeta tenuifolia*.

a. Life History

Lipochaeta tenuifolia has been observed flowering in April (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Lipochaeta tenuifolia typically grows on ridgetops and cliff faces in open areas and protected pockets of diverse mesic forest dominated by ohia at elevations of 370 to 900 meters (1,200 to 3,000 feet) (USFWS 1995, Wagner *et al.* 1990). Associated plants include kookoolau, *Carex meyenii*, ahinahina, and kawelu (USFWS 1995).

c. Current and Historic Ranges and Population Status

Lipochaeta tenuifolia was known from the central Waianae Mountains (Wagner *et al.* 1990). It currently occurs from Kaluakauila Gulch to Kamaileunu Ridge, along Makua-Keaau Ridge, and Mt. Kaala on Federal and State-owned land (HHP 1997). The 9 known populations, in an area of about 8 by 10 kilometers (5 by 6 miles), contain approximately 2,000 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Lipochaeta tenuifolia* are habitat degradation by feral ungulates, particularly goats, competition for light and space from alien plants (Christmas berry, koa haole, molasses grass, daisy fleabane, and strawberry guava), and fire (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. Implementation of the plan may protect this species from fire. Completion of a boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, may help to protect this species from further goat damage (K. Kawelo, pers. comm. 1997). This species is being propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic barrier fencing to protect populations against feral ungulates.

Where feasible, enclosures or strategic barrier fencing should be constructed around populations of *Lipochaeta tenuifolia* that will not be protected from goats by the Army's fencing efforts at Makua. Subsequent control or removal of goats from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Where accessible, populations of this species should be weeded.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State Natural Area Reserves (Mt. Kaala), forest reserves (Makaha-Keaau), and Federal (Army's Makua Military Reservation) lands needs to be developed and implemented.

Lobelia gaudichaudii ssp. *koolauensis* Recovery Priority Number 6

Appendix B contains a line drawing of *Lobelia gaudichaudii* ssp. *koolauensis*.

a. Life History

Lobelia gaudichaudii ssp. *koolauensis* has been observed in flower in September and fruit in December (K. Kawelo, pers. comm. 1997). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Lobelia gaudichaudii ssp. *koolauensis* typically grows on moderate to steep slopes in ohia or ohia-uluhe lowland wet shrublands at elevations between 640 and 730 meters (2,100 and 2,400 feet) (USFWS 1996b). Associated plants include alani, kookolau, naupaka, uki, maile, manono, hapuu, olapa, and kanawao (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Lobelia gaudichaudii* ssp. *koolauensis* was known from 2 populations in the central Koolau Mountains on Oahu (HHP 1997). As a result of searches, the subspecies is currently known from 4 small populations on the Manana Ridge system in the central Koolau Mountains on privately owned land, and on the Army's Schofield Barracks Training Area, East Range. An additional population that is suspected to be *Lobelia gaudichaudii* ssp. *koolauensis* occurs on the Kaipapau-Kawainui summit divide on land leased by the Army for Kawailoa Training Area, however, this cannot be confirmed until the individuals flower (HHP 1997; K. Kawelo, pers. comm. 1998). The total number of plants is estimated to be fewer than 280, about evenly distributed between all populations.

d. Reasons for Decline and Current Threats

The primary threats to the remaining populations of *Lobelia gaudichaudii* ssp. *koolauensis* are habitat degradation and/or destruction by feral pigs, competition with alien plants (Koster's curse narrow leaved carpet grass, glenwood grass), potential rat and slug predation, trampling by hikers, potential overcollection, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor (USFWS 1996b; L. Mehrhoff and C. Russell, pers. comms. 1997).

e. Conservation Measures

Seeds of this subspecies have been collected by the National Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the only known populations of *Lobelia gaudichaudii* ssp. *koolauensis* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed. Where fencing is not feasible due to topography or potential damage to sensitive habitat, other means of ungulate control including snaring should be judiciously used.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect the remaining populations.

3) Maintain adequate genetic stock.

To prevent extinction of *Lobelia gaudichaudii* ssp. *koolauensis*, *ex situ* propagation should be initiated. Propagation material should be collected immediately from the remaining populations.

Lobelia monostachya Recovery Priority Number 5

No line drawing is available for this taxon.

a. Life History

This species has been observed in flower in May and June (R. Fenstenmacher, pers. comm. 1998). Further information is not available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species occurs on steep, sparsely vegetated cliffs in mesic shrubland at an elevation of about 290 meters (950 feet) (USFWS 1996b). Associated plants include ahinahina, *Carex meyenii*, *Psilotum nudum* (moa), and kawelu (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Lobelia monostachya was known only from the Koolau Mountains and had not been seen until recently, since its original discovery in the 1800's in Niu Valley and in the 1920's in Manoa Valley (HHP 1997). However, in 1994 Joel Lau discovered 1 individual in a previously unknown location in Wailupe Valley on State-owned land. Since then, 8 individuals have been found in this area (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Lobelia monostachya* are suspected predation by rats and slugs; competition with alien plants (Christmas berry, Hamakua pamakani, air plant, and molasses grass); and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the low number of individuals in the only known population (USFWS 1996a).

e. Conservation Measures

Lobelia monostachya is being propagated at the Lyon Arboretum (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Control competing alien plant species.

The remaining population should be weeded and protected immediately.

2) Reduce threat of rat predation.

The only population of *Lobelia monostachya* may be seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Lobelia niihauensis Recovery Priority Number 8

Appendix B contains a line drawing of *Lobelia niihauensis*.

a. Life History

Lobelia niihauensis flowers in late summer and early fall. Fruits mature a month to six weeks later. Plants are long-lived and are known to live as long as 20 years (USFWS 1995).

b. Habitat Description

Lobelia niihauensis typically grows on exposed mesic to dry cliffs at an elevation of 100 to 830 meters (330 to 2,720 feet) (USFWS 1995). Associated, plants include kawelu, kookoolau, *Plectranthus parviflorus*, *Lipochaeta* sp. (nehe), and ahinahina (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Lobelia niihauensis* was known from the Waianae Mountains of Oahu, from Uluhulu Gulch to Nanakuli Valley; from western Kauai, from Limahuli Valley to near the Hanapepe River as well as in the east at Nounou Mountain and the Haupu Range; and from the island of Niihau (USFWS 1995). It is now known to be extant only on Kauai and Oahu. On Oahu, this species remains on Kamaileunu Ridge, Mt. Kaala, Kamaileunu, 6 locations in Waianae Kai, 3 locations in Makua Military Reservation, Nanakuli, South Mohiakea Gulch, and 6 locations in Lualualei Naval Magazine on Federal, State and City and County land (HHP 1997). The 19 Oahu populations total between 718 and 753 individuals. On Kauai, this species is found in Waimea Canyon, on Polihale Ridge, along the Na Pali Coast, and in the Haupu Range, on State and private land (HHP 1997). The 14 Kauai populations total between 960 and 2900 individuals. Together with the Oahu plants, 33 populations with approximately 967–2,852 individuals are extant (HHP 1997). The populations on Oahu are located within an area of about 8 by 16 kilometers (5 by 10 miles), and 13 by 16 kilometers (8 by 10 miles) on western Kauai, which is about 37 kilometers (23 miles) from the eastern Kauai population. While some populations are not well documented, at least 14 Oahu populations and 4 Kauai populations contain fewer than 13 individuals.

d. Reasons for Decline and Current Threats

On Oahu, the major threats to *Lobelia niihauensis* are habitat degradation and predation by feral goats, rats, and slugs; fire; military activities; and competition from alien plants (Christmas berry, koa haole, daisy fleabane, Hamakua pamakani, and molasses grass). On Kauai, the major threats are habitat degradation and predation by goats and competition from alien plants (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. Implementation of the plan may aid in protecting this species from fire. Completion of a boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should help to protect this species from further goat damage at Makua-Keaau Ridge (K. Kawelo, pers. comm. 1997). This species is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic barrier fences to protect populations against feral ungulates.

Where feasible, enclosures or strategic barrier fences should be constructed to protect the known populations of *Lobelia niihauensis* from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed. Where fencing is not feasible, aerial goat control may help to protect these plants.

2) Control competing alien plant species within enclosures.

Where accessible, weeds should be removed in the vicinity of these plants.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State Natural Area Reserves (Mt Kaala), forest reserves (Mokuleia and Waianae Kai on Oahu and Na Pali-Kona on Kauai), and Federal (Army's Makua Military Reservation) lands should be developed and implemented.

Lobelia oahuensis Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species was observed in flower during November 1991 (USFWS 1996a). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

The 11 populations are between elevations of 850 and 920 meters (2,800 and 3,000 feet) on summit cliffs in cloud-swept wet forests or in areas of low-shrub cover that are frequently exposed to heavy wind and rain (USFWS 1996a, Lammers 1990). Associated plants include akia, kanawao, manono, hapuu, ohia, uluhe, pilo, uki, *Cheirodendron trigynum* (olapa), *Dubautia laxa* (naenae pua melemele), and *Labordia hosakana* (kamakahala) (HHP 1997; USFWS 1996a).

c. Current and Historic Ranges and Population Status

Historically, *Lobelia oahuensis* was known from Kahana Ridge, Kipapa Gulch, and the southeastern Koolau Mountains of Oahu (USFWS 1996b; St John and Hosaka 1935). Eleven populations totaling about 110 individuals are located on private and State land or on the boundary of private, State, City and County, and Federal lands. *Lobelia oahuensis* grows on steep slopes along Koolau Mountain ridge tops from Waikane and Halawa to Mount Olympus and the summit ridges above Kuliouou and Waimanalo, a distance of about 27 kilometers (17 miles) (HHP 1997, USFWS 1996a). In 1995, Ken Wood of the National Tropical Botanical Garden and Joel Lau of The Nature Conservancy of Hawaii discovered a single mature individual of *Lobelia oahuensis* on the boundary between State land and Schofield Barracks Military Reservation, extending its distribution to the Waianae Mountain

Range of Oahu (USFWS 1996a). Except for 2 populations that contain between 30–40 individuals, the remaining 9 populations all contain fewer than 10 individuals (Mt. Olympus, Kohahuanui, Puu Kona, Aiea-Halawa Valley summit ridge, Kaneohe-Moanalua summit, Kapakahi-Waimanalo summit ridge, Puu Kalena, Eleao, Moanalua).

d. Reasons for Decline and Current Threats

A noxious alien plant, Koster's curse, is the primary threat to *Lobelia oahuensis* because it effectively competes with this species for water, space, light, and nutrients. Additional threats are habitat degradation and predation by feral pigs, predation by rats and slugs, and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining individuals (USFWS 1996a).

e. Conservation Measures

Seeds of this species have been collected by the National Botanical Garden (S. Smith, pers. comm. 1997). It is currently being propagate by the Lyon Arboretum (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of *Lobelia oahuensis* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect populations that have only a few remaining individuals (Mt. Olympus, Kohahuanui, Puu Kona, Aiea-Halawa Valley summit ridge, Kaneohe-Moanalua summit, Kapakahi-Waimanalo summit ridge, Puu Kalena, Eleao, Moanalua), where feasible. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed. Where fencing is not deemed feasible due to topography or potential damage to sensitive summit habitat, other mechanisms for ungulate control, such as snaring should be judiciously implemented.

2) Control competing alien plant species within enclosures.

Specific efforts should be made to immediately weed and protect populations that have only a few remaining individuals (Mt. Olympus, Kohahuanui, Puu Kona, Aiea-Halawa Valley summit ridge, Kaneohe-Moanalua summit, Kapakahi-Waimanalo summit ridge, Puu Kalena, Eleao, Moanalua), where feasible.

4) Reduce threat of rat predation.

Populations of *Lobelia oahuensis* are seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

Melicope lydgatei Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species has been observed in flower in May and in fruit from June to July (USFWS 1996a; K. Kawelo, pers. comm. 1997). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species typically grows in association with koa, ohia, hapuu, maile, uluhe, kopiko, and *Bobea elatior* (ahakea lau nui) on open ridges in mesic forests and occasionally in wet forests at elevations between 410 and 550 meters (1,350 and 1,800 feet) (Stone *et al.* 1990 USFWS 1996a).

c. Current and Historic Ranges and Population Status

Melicope lydgatei was formerly known throughout the Koolau Mountains of Oahu from Hauula to Kahana, Kipapa Gulch to Waimano, and Kalihi Valley to Wailupe Valley (USFWS 1996a). Only 3 populations (fewer than 45 individuals) remain, distributed over a

12-kilometer (7.5-mile) distance. They are along the Peahinaia Trail (40 individuals), along the Poamoho Trail (1 individual) within the Kawailoa Training Area (K. Kawelo, pers. comm. 1998), and along Manana Trail, on State land in the Ewa Forest Reserve (HHP 1997; USFWS 1996a).

d. Reasons for Decline and Current Threats

The primary threats to *Melicope lydgatei* are competition from aggressive alien plants (strawberry guava, and Koster's curse), feral pigs, and risk of extinction due to naturally-occurring events and/or reduced reproductive vigor because of the few individuals remaining and their restricted distribution, and potential predation from the black twig borer (USFWS 1996a).

e. Conservation Measures

The Army has constructed a small exclosure around one individual within the Peahinaia Trail population, which protects it from ungulate damage (K. Kawelo, pers. comm. 1997).

The Lyon Arboretum is propagating this species (G. Koob, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the remaining unfenced individuals and populations of this species to reduce impacts from feral pigs, if feasible. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

The two populations should immediately be weeded and protected, if feasible.

3) Implement promising control methods for the black twig borer suggested by further research.

A number of parasitoids have been introduced to control the beetle, though none of them have become established. Further research on biological control of the beetle will need to proceed cautiously as a number of rare native Hawaiian scolytids are closely related to the black twig borer (P. Conant, pers. comm. 1997; J. Nakatani, *in litt.* 1996).

Melicope saint-johnii Recovery Priority Number 8

No line drawing is available for this taxon.

a. Life History

No information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species typically grows on mesic forested ridges from 500 to 853 meters (1,640 to 2,800 feet) elevation. Associated native plants include mamaki, ohia, *Coprosma longifolia* (pilo), *Hedyotis schlechtendahliana* (kopa), *Labordia kaalae* (kamakahala), and *Psychotria hathewayi* (kopiko) (USFWS 1996b; Takeuchi 1992, Takeuchi and Paquin (s.n.) 1985).

c. Current and Historic Ranges and Population Status

Historically, *Melicope saint-johnii* was known from both the Waianae and Koolau Mountains at Makaha to Mauna Kapu in the Waianae Mountains and Papali Gulch in Hauula, Manoa-Aihualama, Wailupe, and Niu Valley in the Koolau Mountains (HHP 1997; Takeuchi 1992). Today 6 populations of this species are found on Federal (Lualualei Naval Reservation), State, and private land from the region between Puu Kaua and Puu Kanehoa to Mauna Kapu in the southern Waianae Mountains. Fewer than 150 individuals of this species are known (HHP 1997; Takeuchi 1992; Takeuchi and Paquin (s.n.) 1985; J. Lau, pers. comm. 1997). At least three populations contain only 1 individual (North Palawai Gulch, South Ekahanui Gulch, and Lualualei, Halona subdistrict).

d. Reasons for Decline and Current Threats

The primary threats to *Melicope saint-johnii* are habitat degradation and/or destruction by feral goats and pigs; potential predation by the black twig borer; potential fire; and competition with alien plants such as Christmas berry, firetree, Hamakua pamakani, huehue haole, lantana, Maui pamakani, and silk oak; and risk of extinction due to naturally-occurring events and/or reduced reproductive vigor because of the few individuals remaining and their restricted distribution (USFWS 1996b; J. Lau, pers. comm. 1997).

e. Conservation Measures

The Palawai population is within the boundaries of a fenced exclosure that TNCH plans to build in 1998 (W. Fulks, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures should be constructed around the known populations of *Melicope saint-johnii* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (South Ekahanui Gulch, and Lualualei, Halona subdistrict), should immediately be fenced and protected, if feasible. Once these areas are enclosed, a commitment should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (North Palawai Gulch, South Ekahanui Gulch, and Lualualei, Halona subdistrict) should immediately be weeded and protected, if feasible.

3) Maintain adequate genetic stock.

Propagation material should be collected immediately from populations that have only a few individuals (North Palawai Gulch, South Ekahanui Gulch, and Lualualei, Halona subdistrict).

4) Implement promising control methods for the black twig borer suggested by further research.

The black twig borer has been identified as a potential threat to the continued survival of *Melicope saint-johnii*. All of the known individuals suffer slight to severe defoliation and reduced vigor due to infestations of this alien insect. A number of parasitoids have been introduced to control the beetle, though none of them have become established. Further research on biological control of the beetle must proceed cautiously because a number of rare Hawaiian native scolytids are closely related to the black twig borer (P. Conant, pers. comm. 1997; J. Nakatani, *in litt.* 1996).

Myrsine juddii Recovery Priority Number 8

No line drawing is available for this taxon.

a. <u>Life History</u>

Myrsine juddii has been observed in fruit in May (K. Kawelo, pers. comm. 1997). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. <u>Habitat Description</u>

Myrsine juddii typically grows in wet forests dominated by ohia or a mixture of ohia and uluhe at elevations between 580 and 860 meters (1,900 and 2,820 feet) (USFWS 1996b). Associated plants include uki, olapa, *Melicope clusiifolia* (kolokolo mokihana), *Psychotria mariniana* (kopiko), ohia ha (USFWS 1996b).

c. <u>Current and Historic Ranges and Population Status</u>

Myrsine juddii has been reported from only 3 populations in the central Koolau Mountains—the main population along the North Kaukonahua-Kahana Summit divide numbers between 500 and 3,000 individuals, whereas the Puu Kainapuaa to Poamoho Trail population has only 5 individuals and the Peahinaia population is not well documented.

These populations are found on private and State land leased by the DOD for Kawailoa Training Area (HHP 1997).

d. Reasons for Decline and Current Threats

The primary threats to *Myrsine juddii* are habitat degradation and/or destruction by feral pigs, potential impacts from military activities, competition with alien plants such as Koster's curse and strawberry guava, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of extant populations (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

The National Tropical Botanical Garden has collected seed from this species, but it has not been propagated (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of *Myrsine juddii* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Peahinaia and Poamoho Trails) should immediately be weeded and protected.

3) Maintain adequate genetic stock

To prevent extinction of this species, *ex situ* propagation should be initiated. Propagation material should be collected immediately from all extant populations.

Neraudia angulata Recovery Priority Number 5

Appendix B contains a line drawing of *Neraudia angulata.*

a. Life History

Neraudia angulata flowers and fruits from early spring to summer. Fruits mature in about a month (USFWS 1995). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Neraudia angulata typically grows on slopes, ledges, or gulches in diverse mesic forest dominated by lama, at an elevation of 370 to 820 meters (1,200 to 2,700 feet) (USFWS 1995, Wagner *et al.* 1990). Associated plants include aulu and olopua (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Neraudia angulata* was known from almost the entire length of the Waianae Mountains, from Kaluakauila Gulch nearly to Puu Manawahua (USFWS 1995, Wagner *et al.* 1990). This species is currently known from Kaluakauila Gulch along Makua-Keaau Ridge to Makaha-Waianae Kai Ridge on Federal, State, and private land (HHP 1997). The 15 known populations, which are within an area of about 5 by 18 kilometers (3 by 11 miles), are estimated to comprise approximately 110 individuals (HHP 1997). Except for 2 populations that contain between 20–50 individuals, all of the remaining populations contain fewer than 12 individuals.

d. Reasons for Decline and Current Threats

The major threats to *Neraudia angulata* are habitat degradation by feral goats and pigs, military activities, competition from alien plants (Christmas berry, huehue haole, molasses grass, and strawberry guava), fire, and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks in Makua Military Reservation. These actions may aid in protecting this species from the threat of fire. The completion of the boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should also help to protect this species from further goat damage (K. Kawelo, pers. comm. 1997).

The National Tropical Botanical Garden is propagating this species (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Where feasible, enclosures should be constructed around the known populations of *Neraudia angulata* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Populations with only a few remaining individuals (that is, most populations), should immediately be fenced and protected, if feasible. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals should immediately be weeded and protected, if feasible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Waianae Kai) and Federal (Army's Makua Military Reservation) lands needs to be developed and implemented.

Nototrichium humile Recovery Priority Number 8

Appendix B contains a line drawing of *Nototrichium humile*.

a. Life History

Nototrichium humile is found on and at the base of rock cliffs and talus slopes in areas that do not receive full sun all day. Plants have been observed flowering after heavy rain, but flowering is generally heaviest in the spring and summer. Fruits mature a few weeks after flowering (USFWS 1995). In cultivation, this species is known to live for more than a decade (J. Lau, pers. comm. 1997).

b. Habitat Description

Nototrichium humile typically grows at an elevation of 60 to 700 meters (200 to 2,300 feet), on cliff faces, gulches, or steep slopes in remnants of open dry forests often dominated by aulu or lama (USFWS 1995; Wagner *et al.* 1990). Associated species include alahee, ohia ha, *Reynoldsia sandwicensis* (ohe), *Pleomele* sp. (halapepe), *Myrsine lanaiensis* (kolea), and papala kepau (HHP 1997; USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Nototrichium humile* was known from the entire length of the Waianae Mountains, from near Kaena Point to Nanakuli Valley, and from Lualailua Hills on East Maui (USFWS 1995; Wagner *et al.* 1990). This species is still extant on Oahu from Kaluakauila Gulch, along Makua-Keaau Ridge to Makaha-Waianae Kai Ridge and Nanakuli, where it occurs on Federal, State and private lands (HHP 1997; J. Lau, pers. comm. 1997). It is also extant in Maui's Lualailua Hills on private land (HHP 1997). Fourteen of the 15 known populations grow within an area of about 5 by 18 kilometers (3 by 11 miles) in the Waianae Mountains and total 1,489 to 1,519 individuals. The single Maui population is not well documented. At least six populations number fewer than 12 individuals (Lualualei: Mikilua and Pahoa subdistricts, Palehua, Kealia, Kipuna Gulch, and Waianae Kai).

d. Reasons for Decline and Current Threats

On both Oahu and East Maui, the major threats to *Nototrichium humile* are habitat degradation by feral goats, pigs, and cattle; military activities; competition from alien plant species (Christmas berry, koa haole, molasses grass, and strawberry guava); and fire (USFWS 1995).

e. Conservation Measures

One individual of *Nototrichium humile* has been outplanted by TNCH in a fenced exclosure in Honouliuli Preserve (B. Morgan, pers. comm. 1997). As of November, 1997, this plant was in good condition (W. Fulks, pers. comm.). There are two collections (from different sources) at the Pahole mid-elevation Nike site (B. Garnett, pers. comm. 1997).

Approximately 10 of the wild individuals are within the boundaries of a large fenced exclosure at Kahanahaiki Gulch. General weeding efforts within the fenced exclosure may benefit this species (K. Kawelo, pers. comm. 1997).

The National Tropical Botanical Garden has collected seed from this species and it is being propagated at the Waimea Arboretum (S. Smith and D. Orr, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Enclosures or strategic barrier fence should be constructed around the known populations of *Nototrichium humile* to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Specifically, populations that have only a few remaining individuals (Lualualei: Mikilua and Pahoa subdistricts, Palehua, Kealia, Kipuna Gulch, and Waianae Kai) should immediately be fenced and protected. Once these areas have been enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Lualualei: Mikilua and Pahoa subdistricts, Palehua, Kealia, and Pahole Gulch) should immediately be weeded and protected.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Waianae Kai) and Federal (Lualualai Naval Reservation) lands needs to be developed and implemented.

Phlegmariurus nutans Recovery Priority Number 5

Appendix B contains a line drawing of *Phlegmariurus nutans*.

a. Life History

Phlegmariurus nutans (a *Lycopodium* or "clubmoss") has been observed fertile, with spores, in May and December (K. Kawelo, pers. comm. 1998). No other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Phlegmariurus nutans grows on tree trunks, usually on open ridges and slopes in ohia-dominated wet forests and occasionally mesic forests (USFWS 1996a, Hosaka 1937) between 600 and 1,070 meters (2,000 and 3,500 feet) in elevation (Robinson 1914, Selling 1946). The vegetation in those areas typically includes kanawao, kopiko, uluhe, uki, kokio keokeo, and hame (USFWS 1996a).

c. Current and Historic Ranges and Population Status

Historically, *Phlegmariurus nutans* was known from the island of Kauai and from scattered locations in the Koolau Mountains of Oahu bounded by Kaluanui Valley to the north, Paalaa to the west, and Mount Tantalus to the south (Skottsberg 1936, USFWS 1996a). The specimen from Kauai had no specific habitat information associated with the collection. This species is now known from only 3 sites within its historical range: Kaukonahua Ridge, Kaukonahua Gulch, and along Waikane-Schofield Trail on Oahu (HHP 1997; USFWS 1996a). Approximately four individuals remain.

d. Reasons for Decline and Current Threats

The primary threat to *Phlegmariurus nutans* is extinction due to naturally-occurring events and/or reduced reproductive vigor because of the small number of remaining individuals and limited distribution. Additional threats to *Phlegmariurus nutans* are feral pigs and the noxious alien plants, Koster's curse and strawberry guava (USFWS 1996a).

e. Conservation Measures

Propagation was attempted at the National Tropical Botanical Garden but was unsuccessful (M. Chapin, pers. comm. 1998).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of *Phlegmariurus nutans* to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

The 3 remaining populations should immediately be weeded and protected.

Phyllostegia hirsuta Recovery Priority Number 5

Appendix B contains a line drawing of *Phyllostegia hirsuta*.

a. Life History

Phyllostegia hirsuta has been observed in flower in February and in fruit in June (K. Kawelo, pers. comm. 1997). Cultivated material flowered in July (see "Conservation Measures"). No other information on reproductive cycles, longevity, specific environmental requirements, or limiting factors is available.

b. Habitat Description

Phyllostegia hirsuta is usually found on steep, shaded slopes in mesic to wet forests dominated by ohia or a mixture of ohia and uluhe between 600 and 1,100 meters (1,970 and 3,610 feet) elevation (USFWS 1996b). Associated plants include alaa, kanawao, mamaki, pilo, *Hedyotis terminalis* (manono), *Myrsine lessertiana* (kolea lau nui), and native and alien ferns (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Phyllostegia hirsuta* was known from widespread populations in the Waianae and Koolau Mountains on Oahu. It ranged in the Waianae Mountains from the head of Kukuiula (Pahole) Gulch to North Palawai Gulch (HHP 1997). It ranged almost the entire length of the Koolau Mountains, from Pupukea-Kahuku Trail to Palolo (HHP1997). This species' distribution in the Waianae Mountains is now restricted to 10 populations in the southern part of the historical range — from the ridge between Makaha and Waianae Kai to the south fork of North Palawai Gulch (HHP 1997).

The current distribution in the Koolau Mountains is 6 populations scattered over a 10-kilometer (6-mile) length of the summit, from Kawainui Gulch in Kawailoa Training Area to South Kaukonahua drainage (HHP 1997). These populations occur on Federal land in Lualualei Naval Reservation and Schofield Barracks Military Reservation, State land, including Mount Kaala NAR, and private lands, including TNCH's Honouliuli Preserve and land leased by DOD for Kawailoa Training Area.

About 150 to 200 individuals remain in the 16 populations. Several populations number between 20–30 individuals; however, at least 11 populations number fewer than 3 individuals (Kawailoa Training Area, Lualualei, Schofield Barracks, and Waianae Kai Forest Reserve).

d. Reasons for Decline and Current Threats

The primary threats to *Phyllostegia hirsuta* are habitat degradation and/or destruction by feral pigs; potential impacts from military activities; and competition with Christmas berry, Koster's curse, lantana, prickly Florida blackberry, and strawberry guava (USFWS 1996b).

e. Conservation Measures

One accession of seeds was made from State lands in the Koolau Mountains during 1997 resulting in 70+ individuals which flowered in July in the mid-elevation Nike facility in the Waianae Mountains (B. Garnett, pers. comm. 1997).

The Lyon Arboretum and the National Tropical Botanical Garden have propagated this species, and seeds are in storage at the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of this plant to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Immediate fencing and protection should be provided for populations that have only a few remaining individuals (Kawailoa Training Area, Lualualei, Schofield Barracks, and Waianae Kai Forest Reserve), where feasible. Once the populations are fenced, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Kawailoa Training Area, Lualualei, Schofield Barracks, and Waianae Kai Forest Reserve) should immediately be weeded and protected, where feasible.

Phyllostegia kaalaensis Recovery Priority Number 5

No line drawing is available for this taxon.

a. Life History

No information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species is found in mesic mixed (native/alien) forest or papala kepau-aulu forest from 490 to 760 meters (1,610 to 2,500 feet) in elevation (USFWS 1996b). Associated plants include ieie, opuhe, *Claoxylon sandwicense* (poola), and kokio keokeo (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Phyllostegia kaalaensis has been known from only 6 scattered populations in the Waianae Mountains of Oahu (HHP 1997). The 6 populations, containing a total of fewer than 40 plants, are in Waianae Kai (about 30 individuals), Pahole Gulch (6 individuals), central Ekahanui Gulch (1 individual), south Ekahanui Gulch (2 populations, 2 individuals) and Palikea Gulch (1 individual). These populations occur on State land, including Pahole and Mt. Kaala Natural Area Reserve and private land, including TNCH's Honouliuli Preserve (HHP1997).

d. Reasons for Decline and Current Threats

The major threats to *Phyllostegia kaalaensis* are habitat degradation and/or destruction by feral pigs, potential fire; competition with alien plants (Christmas berry, huehue haole, Koster's curse, and strawberry guava), and risk of extinction from naturally-occurring events and/or reduced reproductive vigor, due to the small number of populations and individuals (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. These actions may aid in protecting this species from the threat of fire. The completion of the boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should also help to protect this species from goat damage.

This species is being successfully propagated at the National Tropical Botanical Garden, the Waimea Arboretum, and at DOFAW's mid-elevation Nike facility at Pahole (B. Garnett, G. Koob, D. Orr, and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (Pahole Gulch, Ekahanui Gulch, and Palikea Gulch), should immediately be fenced and protected, if feasible. Once these areas have been enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Pahole Gulch, Ekahanui Gulch, and Palikea Gulch), should immediately be weeded and protected, if feasible.

3) Provide protection from fire.

A coordinated fire protection plan should be developed and implemented for endangered plant species on State Natural Area Reserves (Pahole and Mt. Kaala) and private lands (Honouliuli Preserve).

Phyllostegia mollis Recovery Priority Number 5

No line drawing is available for *Phyllostegia mollis*.

a. Life History

Phyllostegia mollis flowers in the late winter and spring. Plants are relatively short-lived. Their life span is approximately five years (USFWS 1995).

b. Habitat Description

Phyllostegia mollis typically grows on steep slopes and in gulches in diverse mesic to wet forests at an elevation of 450 to 1,830 meters (1,500 to 6,000 feet) (USFWS 1995, Wagner *et al.* 1990). Associated plants include ferns, kopiko, papala kepau (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Phyllostegia mollis* was known from the central and southern Waianae Mountains, from Mt. Kaala to Honouliuli, and from Makiki in the Koolau Mountains of Oahu (USFWS 1995; Wagner *et al.* 1990). It also was known from Molokai and East Maui (USFWS 1995; Wagner *et al.* 1990). This species remains only in Kaluaa Gulch (1 individual), Palawai (45 individuals), Puu Kumakili (50–70 individuals), and on Puu Kalena (19 individuals) in the Waianae Mountains on Oahu, and in Waiopai Gulch (1 individual) on East Maui on Federal, State and private land (HHP 1997; USFWS 1995). The 4 populations in the Waianae Mountains are 4 kilometers (2.5 miles) apart and are estimated to contain approximately 120 to 140 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Phyllostegia mollis* are competition from Christmas berry, habitat degradation and predation by feral pigs, and the small number of extant populations, which makes the species vulnerable to random mass mortality events (USFWS 1995).

e. Conservation Measures

This species is being successfully propagated at the Lyon Arboretum and the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).
The Palawai population is located within the boundaries of a fenced exclosure that TNCH plans to construct in 1998 (W. Fulks, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Kaluaa Gulch on Oahu and Waiopai Gulch on East Maui) should immediately be weeded and protected.

3) Conduct genetic/taxonomic research

Taxonomic research is needed to examine the genetic differences between the Oahu and Maui populations of this species. The Maui population may be separated into its own species (J. Lau, pers. comm. 1997).

Pritchardia kaalae Recovery Priority Number 5

No line drawing is available for this palm.

a. Life History

Pritchardia kaalae plants have been observed in fruit in April, August and October and may fruit throughout the year (K. Kawelo, pers. comm. 1998). No other information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Pritchardia kaalae is typically found on steep slopes and gulches in mesic forest or shrubland between elevations of 460 and 945 meters (1,500 and 3,100 feet). Associated plants include aalii, kolea, kookoolau, mamaki, naenae, ohia, *Eragrostis* sp. (kawelu), and *Tetraplasandra* sp. (ohe) (USFWS 1996b; Read and Hodel 1990).

c. Current and Historic Ranges and Population Status

Historically, *Pritchardia kaalae* was known from scattered populations in the central and north-central Waianae Mountains of Oahu (Beccari and Rock 1921, HHP 1997). Currently 5 populations are known from Manuwai Gulch (several individuals), East Makaleha (51 individuals), Kaumokunui Gulch (about 20 individuals), Waianae Kai-Haleauau summit divide (3 individuals), and Makua-Keaau Ridge (53 individuals), totaling about 130 individuals. These populations are located on State land (including Mt. Kaala Natural Area Reserve) and on Federal land (Makua Military Reservation and Schofield Barracks Military Reservation) (HHP 1997). Three plants in the Palawai Gulch, discovered after *Pritchardia kaalae* was listed, were initially thought to be *Pritchardia kaalae*. They are currently believed to be distinct from other *Pritchardia* in Hawaii based on protein electrophoretic analysis (W. Fulks, pers. comm. 1997).

d. Reasons for Decline and Current Threats

Major threats to *Pritchardia kaalae* are habitat degradation by feral pigs and goats, fruit predation by rats, potential impacts from military activities, competition with alien plants (Christmas berry, Maui pamakani, and prickly Florida blackberry), potential fire, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of populations (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

Four individuals propagated at mid-elevation Nike site were ready for outplanting in 1997, at a site that is still to be determined (B. Garnett, pers. comm. 1997). This species is being successfully propagated at the Lyon Arboretum, the National Tropical Botanical Garden, and the Waimea Arboretum (G. Koob, D. Orr, and S. Smith, pers. comms. 1997).

The Army has also been controlling rats in the vicinity of *Pritchardia kaalae* individuals on Ohikilolo Ridge (K. Kawelo, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

Where feasible, enclosures should be constructed around the known populations of this species to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (Manuwai Gulch and Waianae Kai-Haleauau summit divide), should immediately be fenced and protected, if feasible. Once these areas have been enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Manuwai Gulch and Waianae Kai-Haleauau summit divide), should immediately be weeded and protected, where accessible.

3) Reduce threat of rat predation.

Populations of this plant are seriously threatened by rat predation. A management plan to control rats should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

4) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Mt. Kaala Natural Area Reserve) and Federal (Makua Military Reservation and Schofield Barracks Military Reservation) lands needs to be developed and implemented.

Sanicula mariversa Recovery Priority Number 5

Appendix B contains a line drawing of *Sanicula mariversa*.

a. Life History

Sanicula mariversa is known to flower from February through May, and fruits can be found until August. Dry fruits remain on infructescences for a long time and may persist beyond August (K. Kawelo, pers. comm. 1997).

b. Habitat Description

Sanicula mariversa typically grows on well-drained, dry slopes at an elevation of 750 to 850 meters (2,500 to 2,800 feet) (USFWS 1995, Wagner *et al.* 1990). Associated species include *Carex meyenii,* kawelu, and ohia (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Sanicula mariversa* was known from the central Waianae Mountains, from Makua-Keaau Ridge to Kaluaa-Lualualei Summit Ridge (USFWS 1995). This species is now extant only at Makua-Keaau Ridge on Federal and State-owned land (HHP 1997). The 2 known populations, which are about 0.6 kilometers (0.4 miles) apart, contain approximately 75 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Sanicula mariversa* are habitat degradation by feral goats, fire, erosion, competition from alien plant species (Christmas berry and molasses grass), trampling by humans on or near trails, and the risk of extinction due to the small number of populations (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan that includes realigning targets and establishing firebreaks. These actions may aid in protecting this species from the threat of fire. The completion of the boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should also help to protect this species from further goat damage. The Army has conducted some erosion control which has helped stabilize one population on Makua-Keaau Ridge (K. Kawelo, pers. comm. 1997).

This species is being successfully propagated at the National Tropical Botanical Garden and at DOFAW's mid-elevation Nike site at Pahole (B. Garnett and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral goats.

Enclosures should be constructed around the two known populations to reduce impacts from feral goats. Subsequent control or removal of goats from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

The remaining populations should immediately be weeded and protected.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Makua Keaau) and Federal lands (Army's Makua Military Reservation) needs to be developed and implemented.

Schiedea kaalae Recovery Priority Number 5

Appendix B contains a line drawing of *Schiedea kaalae*.

a. Life History

This plant has been observed in flower from March through June (USFWS 1995). Based on field and greenhouse observations, *Schiedea kaalae* has perfect flowers (Wagner *et al.* 1990).

A series of experimental self-pollinations, within-population crosses, and crosses among populations have demonstrated that *Schiedea kaalae* experiences moderately strong inbreeding depression (Weller and Sakai, unpublished data). These results indicate that reductions in population size could result in expression of inbreeding depression in seedlings, with potentially deleterious consequences for the long-term persistence of this species.

Consistent with the evidence for inbreeding depression, *Schiedea kaalae* appears to be an outcrossing species. Under greenhouse conditions, flowers do not set fruit unless pollinated. In the field, this species was observed being visited by the introduced syrphid fly

Simosyrphus grandicornis. The fly did not appear to be foraging for nectar but may have been feeding on pollen (Weller *et al.* 1990).

Individuals of *Schiedea kaalae* appear to be long-lived, but there is no evidence of regeneration from seed under field conditions. Seedlings of *Schiedea kaale*, like those of other *Schiedea* species in mesic or wet sites are apparently consumed by introduced slugs and snails, which have been observed feeding on *Schiedea membranacea*, a mesic forest species from Kauai. *Schiedea* occurring in dry areas produce abundant seedlings following winter rains, presumably because dry areas have fewer alien consumers (S. Weller, pers. comm. 1997).

b. Habitat Description

Schiedea kaalae typically grows on steep slopes and shaded sites in diverse mesic forests at an elevation of 210 to 790 meters (700 to 2,600 feet) (USFWS 1995). Associated species include hoio and *Pisonia umbellifera* (papala kepau) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Schiedea kaalae* was known from the north-central and south-central Waianae Mountains and the northern Koolau Mountains of Oahu (USFWS 1995). This species remains on State and private lands at Pahole Gulch, Kaluaa Gulch, Pohakea Pass, and Puu Kaua and Palawai Gulch in the Waianae Mountains and at Maakua Gulch and Makaua Stream in the Koolau Mountains (HHP 1997; Wagner *et al.* 1990). The 5 known populations in the Waianae Mountains, which are distributed over an area of about 1.6 by 16 kilometers (1 by 10 miles), and the 2 known populations in the Koolau Mountains, which are about 7 kilometers (4 miles) apart, contain only 13 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Schiedea kaalae* are habitat degradation by feral pigs and goats, competition from alien plant species (Christmas berry, Maui pamakani, huehue haole, Koster's curse, molasses grass, and firetree), fire, predation by introduced slugs and snails, and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

Fencing and removal of feral pigs in the Pahole drainage was completed by DOFAW in July 1997 (T. Takahama, pers. comm. 1997). Weeding of strawberry guava, Christmas berry, and Koster's curse continues in the surrounding areas (T. Takahama, pers. comm. 1997). TNCH has plans to build a fenced exclosure in the Palawai area that should help to protect the individuals reported from this area (W. Fulks, pers. comm. 1997).

One seed accession was completed in 1997 from the Kaawa site and 130 individuals are now housed in the mid-elevation Nike site ready for outplanting at a still to be determined site (B. Garnett, pers. comm. 1997). This species is also being successfully propagated at the National Tropical Botanical Garden, the Lyon Arboretum, and the Waimea Arboretum (S. Smith, G. Koob and D. Orr, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral ungulates.

In addition to the work completed in Pahole Gulch, enclosures should be constructed around the other known populations of this plant to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Once these populations are enclosed, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

The remaining populations should immediately be weeded and protected, if feasible.

3) Control of introduced snails and slugs.

Control of introduced snails and slugs is essential for protection of this species. This species reproduces prolifically under greenhouse conditions. The lack of seedlings in the field seems, therefore, almost certainly to be the result of grazing by alien snails and slugs. Evidence from other species of *Schiedea* that occur in mesic areas suggests that these snails and slugs consume seeds of all the species, and probably a substantial portion of the seed crop. Methods to control their predation on seeds and/or seedlings of this species need to be found and implemented (S. Weller, pers. comm. 1997).

4) Research on pollinators.

Research on pollinators is necessary because of the possibility that declines in native pollinator fauna might increase levels of inbreeding, and result in the expression of inbreeding depression. Estimates on inbreeding depression for this species are not available (S. Weller, pers. comm. 1997).

5) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State (Pahole NAR) and private lands (Honouliuli Preserve) needs to be developed and implemented.

Schiedea kealiae Recovery Priority Number 8

Appendix B contains a line drawing of *Schiedea kealiae*.

a. Life History

Schiedea kealiae has been observed in flower in December (K. Kawelo, pers. comm. 1997).

A series of self-pollinations, intra-populational crosses, and crosses among populations have demonstrated that many related *Schiedea* sp. experience moderately strong inbreeding depression (Weller and Sakai, unpublished data). These results indicate that reductions in population size could result in expression of inbreeding depression among seedlings, with potentially deleterious consequences for the long term persistence of this species (Weller *et al.* 1990).

Individuals of *Schiedea kealiae* appear to be long-lived, but there is no evidence of regeneration from seed under field conditions. Seedlings of *Schiedea* species occurring in mesic or wet sites are apparently consumed by introduced slugs and snails, which have been observed feeding on *Schiedea membranacea*, a mesic forest species from Kauai. *Schiedea* occurring in dry areas produce abundant seedlings following winter rains, presumably because dry areas have fewer alien consumers (S. Weller, pers. comm. 1997).

b. Habitat Description

Schiedea kealiae is usually found on steep slopes and cliff faces at elevations from 60 to 305 meters (200 to 1,000 feet), in dry remnant *Erythrina sandwicensis* (wiliwili) or aulu forest (USFWS 1996b). Associated plants include alahee, kookoolau, *Myoporum sandwicense* (naio), and ilima (USFWS 1996b, Wagner *et al.* 1990).

c. Current and Historic Ranges and Population Status

Historically, *Schiedea kealiae* was known from the northern Waianae Mountains and one collection from the Palikea area, near the southern end of the same mountain range (USFWS 1996b). Currently 4 populations totaling between 300 and 500 plants are located on the cliffs above Dillingham Airfield and Camp Erdman and at Kaena Point at the northern end of the Waianae Mountains. These populations occur on private land, State land (including land leased by DOD at Kaena Military Reservation), and Federal land on Dillingham Military Reservation (HHP 1997; J. Lau, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Schiedea kealiae* are competition with alien plants (Christmas berry and koa haole), predation by introduced slugs and snails, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of existing populations. The Kaena Point population is additionally threatened by naturally-occurring rock slides and fire (USFWS 1996b; C. Russell, pers. comm. 1997).

e. Conservation Measures

This species is being successfully propagated at the National Tropical Botanical Garden and the Waimea Arboretum. Seeds are also in storage at the National Tropical Botanical Garden (D. Orr and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Control competing alien plant species.

The remaining populations should immediately be weeded and protected, if feasible.

2) Control of introduced snails and slugs.

Snail and slug control is essential to protect this species. Evidence from other species of *Schiedea* that occur in mesic areas suggests that alien snails and slugs probably consume a substantial portion of the seed crop. Methods to control their predation on seeds and/or seedlings of this species need to be found and implemented (S. Weller, pers. comm. 1997).

3) Research on pollinators.

Research on pollinators is necessary because declines in the native pollinator fauna might increase levels of inbreeding, and result in the expression of inbreeding depression. Estimates of inbreeding depression for this species are not available (S. Weller, pers. comm. 1997).

4) Reduce substrate loss.

Implement methods to reduce the impact of erosion, landslides, and rockslides to the Kaena Point population.

5) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on Federal (Dillingham), State (Kaena Pt.), and private lands (Kaena Pt.) should be developed and implemented.

Silene perlmanii Recovery Priority Number 5

No drawing is available for this species.

a. <u>Life History</u>

Silene perlmanii flowers in the spring, depending on climatic conditions. Flowers last for a day. Fruits develop in a few weeks (USFWS 1995).

b. Habitat Description

Silene perlmanii typically grows on cliff faces in diverse mesic forest at an elevation of 790 meters (2,600 feet) (USFWS 1995; Wagner *et al.* 1990). Associated species include *Plantago princeps* (laukahi kuahiwi) (USFWS 1995).

c. Current and Historic Ranges and Population Status

Silene perlmanii was discovered in the 1980s and was known from a few individuals in two populations in the southern Waianae Mountains on Federal and privately owned land (USFWS 1995; Wagner *et al.* 1990,). The populations were about 1.6 kilometers (1 mile) apart at Palikea and Palawai Gulch (HHP 1997; USFWS 1995). As of December 1997, no individuals are known to be extant in the wild (M. Bruegmann, pers. comm. 1998).

d. Reasons for Decline and Current Threats

The major threats to *Silene perlmanii* are competition from alien plant species (Christmas berry, firetree, and molasses grass), feral pigs, and the risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of individuals, if any, remain (USFWS 1995).

e. Conservation Measures

This species is being propagated at the Lyon Arboretum and the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Conduct surveys.

Surveys of appropriate habitat in historical locations in the Waianae Mountains are needed to determine if any extant wild populations of this species exist.

2) Maintain adequate genetic stock.

To prevent extinction of this species, *ex situ* propagation should be expanded immediately if extant individuals are located.

3) Establish new populations.

Begin establishing new populations of *Silene perlmanii* within its historical range, in areas that are managed to minimize the impacts of feral ungulates and alien plants. The Nature Conservancy of Hawaii has plans to construct a 90-acre fence that will include the site where this plant was last seen. This exclosure would be an ideal place to outplant individuals.

Stenogyne kanehoana Recovery Priority Number 5

Appendix B contains a line drawing of *Stenogyne kanehoana.*

a. Life History

Stenogyne kanehoana generally flowers from February through March, but flowering depends on precipitation and flowers have been noted from January to as late as April. Fruits mature within six weeks. The life span of this species appears to be about 7–12 years (USFWS 1995).

b. Habitat Description

The remnant population of *Stenogyne kanehoana* was found under a canopy of mesic forest trees on a ridge leading to the summit of Puu Kanehoa (USFWS 1995).

c. Current and Historic Ranges and Population Status

Stenogyne kanehoana is known from the east ridge of Puu Kanehoa, Waianae Mountains, near the summit of the ridge connecting Puu Kanehoa with Puu Hapapa to the north and Puu Kaua to the south, a distance totaling approximately 2.8 kilometers (1.75 miles) (USFWS 1995). The last remnant population consisting of two plants near the summit of Puu Kanehoa on privately owned land was found dead recently (HHP 1997; J. Crummer, pers. comm. 1997).

d. Reasons for Decline and Current Threats

Although no *Stenogyne kanehoana* populations are known in the wild, some remnant individuals may occur. The major threats to those individuals are habitat degradation and competition for space, water, light, and nutrients by naturalized, alien vegetation (especially Koster's curse). The extremely small number of potential individual plants and their restricted distribution increases the potential for extinction from naturally-occurring events. Other potential threats which have been suggested include fire and deforestation, but, at present, these probably are not serious threats to the species (USFWS 1995). Feral pigs and hikers are also thought to be a threat to this species (T. Rubenstein, pers. comm. 1997).

e. Conservation Measures

Stenogyne kanehoana is being propagated at the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Conduct surveys.

Surveys in appropriate habitat in historical locations in the Waianae Mountains are needed to determine if there are additional extant wild populations of this species.

2) Maintain adequate genetic stock.

To prevent extinction of this species, *ex situ* propagation should be expanded immediately if extant individuals are located.

3) Enhance wild populations and establish of new populations.

Enhancement of any remaining wild populations by outplanting should be conducted as soon as adequate propagated material becomes available, and fencing and weed control, as appropriate, are underway. Establishment of new populations within the historical range of *Stenogyne kanehoana* should be initiated in areas that are managed to minimize the impacts of feral ungulates and alien plants.

Tetramolopium filiforme Recovery Priority Number 2

Appendix B contains a line drawing of *Tetramolopium filiforme*.

a. Life History

In cultivation, *Tetramolopium filiforme* germinates in about three weeks. Fifteen weeks after germination, the plants are approximately 9 centimeters (3.5 inches) high and they produce their first buds. The first blossoms are noted about eighteen weeks after germination. During growth an inflorescence forms at the apex of each shoot while new shoots develop laterally (Obata 1976).

Tetramolopium filiforme is relatively short-lived and usually lives less than five years. In the wild it usually flowers in the late winter or spring but flowering can also be induced by heavy rainfall (USFWS 1995).

b. Habitat Description

Tetramolopium filiforme typically grows on dry cliff faces and ridges at an elevation of 340 to 900 meters (1,100 to 3,000 feet) (USFWS 1995). Associated species include aalii, ahinahina, and *Schiedea mannii* (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Tetramolopium filiforme* was known from the northern Waianae Mountains, from Ohikilolo Ridge, Keaau Valley, and Makaha Valley (USFWS 1995; Lowrey 1990). This species remains in Keaau Valley (about 25 individuals), Kahanahaiki Valley (20 individuals), Makua-Keaau Ridge (about 1,500 individuals), and Lualualei on Federal land. On State land this species remains at Puu Kawiwi (2 individuals) and on City and County of Honolulu land at Waianae Kai. The 5 known populations, which are distributed over an area of about 3.2 by 8 kilometers (2 by 5 miles), are estimated to contain approximately 1,550 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Tetramolopium filiforme* are habitat degradation by feral goats, competition from alien plant species (Christmas berry, koa haole, molasses grass, and daisy fleabane), fire, military activities, and a risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of remaining populations and trampling or collection by humans on or near trails (USFWS 1995).

e. Conservation Measures

The Army has adopted a fire management plan which includes realigning targets and establishing firebreaks. This may aid in protecting this species from the threat of fire. The completion of the boundary fence on the south and southeast perimeter of Makua Valley and continued goat control efforts, though limited, should help to protect the remaining population at Makua Military Reservation from further goat damage (K. Kawelo, pers. comm. 1997).

This species has been propagated at the National Tropical Botanical Garden (G. Koob and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic barrier fence to protect populations against feral goats.

Enclosures or strategic barrier fences should be constructed around the known populations of this species to reduce impacts from feral goats. Subsequent control or removal of goats from these areas will alleviate their impact on native ecosystems. Specific efforts should be made to immediately fence and protect those populations that have only a few remaining individuals (Puu Kawiwi). A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Where feasible, populations that have only a few remaining individuals (Puu Kawiwi) should immediately be weeded and protected.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Waianae Kai and Makua-Keaau) and Federal (Army's Makua Military Reservation) lands should be developed and implemented.

4) Conduct research on genetic distinctiveness.

Conduct research on the genetic distinctiveness of the two varieties of *Tetramolopium filiforme* (*T. f.* var. *filiforme* and *T. f.* var. *polyphyllum*) (J. Lau, pers. comm. 1997).

Tetramolopium lepidotum* ssp. *lepidotum Recovery Priority Number 3

Appendix B contains a line drawing of *Tetramolopium lepidotum* spp. *lepidotum*.

a. Life History

Tetramolopium lepidotum ssp. *lepidotum* is a short-lived perennial that has been observed producing fruit and flowers from April through July (USFWS 1995). No further other information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Tetramolopium lepidotum ssp. *lepidotum* typically grows on grassy ridgetops, slopes, or west-facing cliffs in mesic forest at an elevation of 370 to 940 meters (1,200 to 3,100 feet) (USFWS 1995). Associated species include kookoolau, and ohia (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Tetramolopium lepidotum* ssp. *lepidotum* was known from nearly the entire length of the Waianae Mountains, from Makua Valley to Cachexia Ridge, as well as from the island of Lanai (Lowrey 1990, USFWS 1995). This taxon remains on Federal, State, and privately owned land on Kuma Kakii (2–3 individuals), Waianae Kai (2 individuals), and Puu Kaua (40–60 individuals) (HHP 1997; USFWS 1995) on Oahu. A total of 3 populations of approximately 44–63 individual plants are currently known.

d. Reasons for Decline and Current Threats

The major threats to *Tetramolopium lepidotum* ssp. *lepidotum* are competition from alien plant species (Christmas berry, daisy fleabane, firetree, and molasses grass), habitat degradation and predation by goats and pigs, fire, trampling or collection by humans on or along trails, and the small number of populations (USFWS 1995).

e. Conservation Measures

TNCH has outplanted 3 individuals in a fenced exclosure within Honouliuli Preserve (B. Morgan, pers. comm. 1997). These individuals have since died, yet two healthy *Tetramolopium lepidotum* ssp. *lepidotum* have sprouted near the exclosure. One of these was flowering in May 1997 and its vigor was rated as moderate. This species is also being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic barrier fence to protect populations against feral ungulates.

Where feasible, construct enclosures or strategic barrier fence around the known populations of this plant to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Special effort should be made to immediately fence and protect the populations with only a few remaining individuals (Kuma Kakii and Waianae Kai Forest Reserve). Once these areas have been fenced, commitments should be developed for their long-term stewardship and conservation.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Kuma Kakii and Waianae Kai Forest Reserve) should immediately be weeded and protected where accessible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserves (Waianae Kai), Federal (Schofield Barracks–West Range), and private lands (Honouliuli Preserve) should be developed and implemented.

Tetraplasandra gymnocarpa Recovery Priority Number 5

No line drawing is available for this species.

a. Life History

This species was observed in flower and fruit in November 1991 (USFWS 1996a) and in fruit in May and September (K. Kawelo, pers. comm. 1997). No further information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Tetraplasandra gymnocarpa is typically found on windswept summit ridges or in gullies in wet or sometimes mesic forests between elevations of 250 and 850 meters (820 and 2,790 feet) with such associated plants as akia, amau, ohia, olapa, uluhe, uki, ieie, kanawao, kopiko, kamakahala, *Hedyotis fosbergii* (manono), kookoolau, *Dubautia laxa* (naenae pua melemele), and hapuu (HHP 1997, Lowrey 1990, USFWS 1996a).

c. Current and Historic Ranges and Population Status

Tetraplasandra gymnocarpa was historically known from Punaluu, Waikakalaua Gulch, Mount Olympus, and the region between Niu and Wailupe, all in the Koolau Mountains of Oahu (Degener 1938; USFWS 1996a). This species was also sighted in the Waianae mountain range at Palikea in 1954. Currently, 17 populations are scattered along the summit ridges of the Koolau Mountains over a distance of 45 kilometers (28 miles), from the region of Paumalu at the northern extreme to Kuliouou and Waimanalo at the southeasternmost point (HHP 1997, USFWS 1996a). Fewer than 200 individuals are known (J. Lau, pers. comm. 1997).

d. Reasons for Decline and Current Threats

The major threats to *Tetraplasandra gymnocarpa* are competition with the alien plant taxa Koster's curse and strawberry guava, habitat degradation by feral pigs, and reduced reproductive vigor due to the species' limited gene pool, a consequence of the small number of extant individuals (USFWS 1996a).

e. Conservation Measures

The National Tropical Botanical Garden has attempted propagation of seeds with no germination.

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Once these areas have been enclosed, commitments should be developed for their long-term stewardship and conservation. Where fencing is not feasible due to topography or potential damage to sensitive summit habitat, other means of ungulate control, including snaring, should be implemented judiciously.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals should immediately be weeded and protected.

3) Maintain adequate genetic stock.

To prevent extinction of *Tetraplasandra gymnocarpa*, *ex situ* propagation should be initiated. Propagation material should be collected immediately from the remaining populations.

Trematolobelia singularis Recovery Priority Number 5

Appendix B contains a line drawing of *Trematolobelia singularis*.

a. Life History

This species has been observed in flower in October (Obata *et al.* 1985). No information exists on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

This species usually grows on steep, windswept cliff faces or slopes in ohia-uluhe montane wet shrubland from 700 to 960 meters (2,300 to 3,150 feet) elevation. Associated plants include akia, alani, amau, hapuu, kanawao, and naenae pua melemele (USFWS 1996b; Lammers 1990; Obata 1988; St. John 1982).

c. Current and Historic Ranges and Population Status

Trematolobelia singularis has been reported only from the southern Koolau Mountains (USFWS 1996b). Approximately 165 plants are known from 3 populations — Moanalua-Tripler Ridge summit to Puu Keahiakahoe (50 individuals), Konahuanui (40 individuals), and Puu Lanipo (75 individuals). These populations are found on land belonging to private owners, the State, and the Federal government (Omega Coast Guard Station) (HHP 1997; Lammers 1990).

d. Reasons for Decline and Current Threats

Habitat degradation by feral pigs, potential predation by rats and slugs, competition with the aggressive alien plant Koster's curse, and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of extant populations are serious threats to *Trematolobelia singularis* (USFWS 1996b; J. Lau and C. Russell, pers. comms. 1997).

e. Conservation Measures

No conservation measures have been taken for this species.

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Where feasible, enclosures should be constructed around the known populations of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Once these areas are enclosed, commitments should be developed for their long-term stewardship and conservation. In areas where fencing is not feasible due to topography or potential damage to sensitive summit habitat, consideration should be given to other means of ungulate control, including snaring.

2) Control competing alien plant species within enclosures.

The remaining populations should immediately be weeded and protected, as feasible.

3) Reduce threat of rat predation.

Rat predation may threaten the 3 populations of this species. A rat control plan should be developed and implemented. This should include the use of the currently-approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide.

4) Maintain adequate genetic stock

To prevent extinction of this species, *ex situ* propagation should be initiated. Propagation material should be collected immediately from all extant populations.

Urera kaalae Recovery Priority Number 5

Appendix B contains a line drawing of *Urera kaalae*.

a. Life History

Urera kaalae has been observed flowering in the spring. It is difficult to predict when seeds will be produced, and, when they are produced, they are often sterile. This may be an indication of pollinator limitation. Plants are fast-growing (USFWS 1995).

b. Habitat Description

Urera kaalae typically grows on slopes and in gulches in diverse mesic forest dominated by papala kepau at an elevation of 300 to 820 meters (980 to 2,700 feet) (USFWS 1995; Wagner *et al.* 1990). Associated species include alaa, poola, ieie, mamaki, *Urera glabra,* kopiko, lama, papala kepau, and olopua (HHP 1997; USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Urera kaalae* was known from the central to southern windward Waianae Mountains, from Waianae Uka to Kupehau Gulch (USFWS 1995, Wagner *et al.* 1990). This species now occurs only in North and South Ekahanui, Pualii, Napepeiauolelo, Halona, and Kaluaa gulches, North and South Palawai, Schofield Barracks Military Reservation and Waianae Kai on Federal, State, City and County, and privately owned land (HHP 1997). The 10 known populations, which are sparsely distributed over an area of about 4 by 11.2 kilometers (2.5 by 7 miles), contain approximately 44 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Urera kaalae* are habitat degradation by feral pigs, competition from alien plant species (Christmas berry, firetree, huehue haole, molasses grass, and strawberry guava), fire, and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

TNCH outplanted 3 individuals in 1995 in a fenced exclosure near existing wild populations in Honouliuli Preserve. As of 1997, only one had survived and its vigor is rated moderate (W. Fulks, pers. comm. 1997). This population is monitored regularly. TNCH has also recently searched for populations in Kaluaa and South Ekahanui gulches to monitor and conduct threat management but was only able to find isolated individual plants (B. Morgan, pers. comm. 1997). TNCH has plans to construct an exclosure at Palawai in 1998 which should help to protect individuals reported from this area. This species is also being successfully propagated at the National Tropical Botanical Garden and the Waimea Arboretum (D. Orr and S. Smith, pers. comms. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations, each of which contains fewer than 10 individuals, of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. A commitment should be developed for long-term stewardship and conservation of these areas once they have been enclosed.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Honouliuli Preserve, Waianae Kai, and Lualualei-Nanakuli Ridge), should immediately be weeded and protected, as feasible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on State forest reserve (Waianae), Federal (Lualualei Naval Reservation) and private (Honouliuli Preserve) lands needs to be developed and implemented.

Viola chamissoniana* spp. *chamissoniana Recovery Priority Number 3

Appendix B contains a line drawing of *Viola chamissoniana* spp. *chamissoniana.*

a. Life History

Viola chamissoniana ssp. *chamissoniana* has been observed in fruit and flower in April, August and October (K. Kawelo, pers. comm. 1998). No further information is available on flowering cycle, pollination vectors, seed dispersal agents, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Viola chamissoniana ssp. *chamissoniana* typically grows on dry cliffs in mesic shrubland at elevations of 700 to 1,000 meters (2,300 to 3,040 feet) (USFWS 1995). Associated species include ahinahina, kookoolau, *Carex meyenii,* kawelu, ohia, and pukiawe (USFWS 1995).

c. Current and Historic Ranges and Population Status

Historically, *Viola chamissoniana* ssp. *chamissoniana* was known from the central and southern Waianae Mountains, from Makaleha Valley to Cachexia (USFWS 1995). This taxon now occurs on Kamaileunu Ridge (3 individuals), Palikea Ridge (between Nanakuli and Lualualei) (5 individuals), Puu Hapapa (6 individuals), Makua-Keaau Ridge (about 220 individuals), Halona (3 individuals), and Puu Kumakalii (20 individual) on Federal and City/County land (HHP 1997). The 6 known populations, which are scattered over an area of about 4 by 13.6 kilometers (2.5 by 8.5 miles), contain 257 individuals (HHP 1997).

d. Reasons for Decline and Current Threats

The major threats to *Viola chamissoniana* ssp. *chamissoniana* are habitat degradation by feral goats and pigs, competition from the alien plant species (Christmas berry, daisy fleabane, Maui and Hamakua pamakani, and molasses grass), fire, and the small number of extant individuals (USFWS 1995).

e. Conservation Measures

This species is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures or strategic barrier fence to protect populations against feral ungulates.

Enclosures or fenced barriers should be constructed around the known populations of this plant to reduce impacts from feral ungulates. Subsequent control or removal of ungulates from these areas will alleviate their impact on native ecosystems. Populations that have only a few remaining individuals (Kamaileunu Ridge, Palikea Ridge, Puu Hapapa, Halona, and Puu Kumakalii), should immediately be fenced and protected, if feasible. Once these areas are enclosed, commitments should be developed for their long-term stewardship and conservation. In areas where fencing is not feasible due to topography, other means of ungulate control such as aerial eradication of goats should be implemented.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (Kamaileunu Ridge, Palikea Ridge, Puu Hapapa, Halona, and Puu Kumakalii), should immediately be weeded and protected, if feasible.

3) Provide protection from fire.

A coordinated fire protection plan for endangered plant species on Honolulu City and County and Federal (Army's Makua Military Reservation) lands needs to be developed and implemented.

4) Determine genetic distinctiveness of *Viola chamissoniana* ssp. *tracheliifolia*.

Research should be conducted on the subspecific genetic distinctiveness of *Viola chamissoniana* due to taxonomic status concern (J. Lau, pers. comm. 1997).

Viola oahuensis Recovery Priority Number 5

Appendix B contains a line drawing of *Viola oahuensis*.

a. Life History

Viola oahuensis has been observed flowering in August and September (K. Kawelo, pers. comm. 1997). No further information is available on reproductive cycles, longevity, specific environmental requirements, or limiting factors.

b. Habitat Description

Viola oahuensis is generally found on exposed, windswept ridges of moderate to steep slope in wet ohia-uluhe shrublands from 700 to 850 meters (2,300 to 2,800 feet) elevation (USFWS 1996b). This species typically grows among wind-stunted naenae pua melemele, akia, manono, hame, ohia ha, alani, kookoolau, uki, amau, ohia ha, and ohelo (*Vaccinium* sp.) (USFWS 1996b).

c. Current and Historic Ranges and Population Status

Historically, *Viola oahuensis* was known from 17 populations in the Koolau Mountains of Oahu scattered over about a 37-kilometer (23-mile) distance from Puu Kainapuaa to Palolo (USFWS 1996b). The 8 extant populations, which total fewer than 180 individuals, are now found from the Kawainui-Koloa summit divide to the Waimalu-Koolaupoko divide over a 20 kilometers (12 miles) distance. Two populations (Koolau summit between Manana and Kipapa and Waimalu-Koolaupoko divide) contain between 50–100 individuals; however, the remaining populations contain fewer than 10 individuals (2 populations along the Peahinaia Trail, 4 populations at the Kawanui-Koloa summit divide, one population at Kahana-S. Kaukonahua, and 3 populations at the Koolau summit between Waimano and Kipapa) . These populations are found on DOD land and private land, including land leased by DOD for Kawailoa Training Area (HHP 1997). Farther to the south, at the summit of Moanalua, a single plant, last seen alive in 1991, has since died (USFWS 1996b).

d. Reasons for Decline and Current Threats

The primary threats to *Viola oahuensis* are habitat degradation and/or destruction by feral pigs; potential impacts from military activities; competition with Koster's curse, strawberry guava, Hilo grass; and risk of extinction from naturally-occurring events and/or reduced reproductive vigor due to the small number of populations (USFWS 1996b).

e. Conservation Measures

This species is being propagated at the National Tropical Botanical Garden (S. Smith, pers. comm. 1997).

f. Needed Recovery Actions

1) Construct enclosures to protect populations against feral pigs.

Enclosures should be constructed around the known populations of this species to reduce impacts from feral pigs. Subsequent control or removal of pigs from these areas will alleviate their impact on native ecosystems. Immediate fencing and protection are needed for populations that have only a few remaining individuals (scattered locations along the Peahinaia Trail, Kawanui-Koloa summit divide, Opaeula-Kaluanui summit divide, and Kaukonahua Ridge). Once these areas are enclosed, commitments should be developed for their long-term stewardship and conservation. In areas not suitable for fencing due to topography or potential damage to sensitive summit habitat, other means of pig control, such as snaring, should be judiciously implemented.

2) Control competing alien plant species within enclosures.

Populations that have only a few remaining individuals (scattered locations along the Peahinaia Trail, Kawanui-Koloa summit divide, Opaeula-Kaluanui summit divide, and Kaukonahua Ridge), should immediately be weeded and protected, as feasible.

F. Overall Recovery Strategy

The 66 species covered in this plan are all dangerously close to extinction due to their extremely low numbers (most number fewer than 100 individuals in the wild) and their limited distributions. Immediate action must be taken to stabilize the few remaining wild populations. These actions include propagation and maintenance of genetic stock *ex situ,* and protection of remaining wild individuals from threats. Current threats to the species should be managed through fencing and/or hunting and possibly snaring to control ungulates; control of alien plants via manual, chemical, and biological control; protection from fire; control of rodents; protection from human disturbance; a comprehensive monitoring program; and, if necessary, protection from insects, snails, slugs, and disease. Simultaneously, surveys should be planned to determine the status of the four species with no known extant individuals (*Cyanea truncata, Cyrtandra crenata, Silene perlmanii,* and *Stenogyne kanehoana*), and those populations of other species that have not been observed in recent years (*Cyrtandra polyantha*). Individuals of these species may exist in former habitats, or may be present in areas that have not been surveyed recently.

Secondly, management units should be delineated to conserve not only these taxa, but their habitats as well. These units should be managed to preserve as many native species (flora and fauna) as possible, through threat-control and forest-restoration programs.

The next step in the recovery of these species is augmentation of small populations and re-establishment of new populations within the historical range of the species, when necessary to meet down/delisting objectives. This includes selection of areas for augmentation and re-establishment, determination of the best methods for *ex situ* propagation and transplanting, selection of the best genetic stock for each area, propagation of suitable stock, preparation of sites for seeding and/or transplanting, and monitoring and maintenance of new individuals and populations as they are established.

A research program is needed to study, for each taxon in the plan, its growth and reproductive viability, parameters of viable populations, reproductive strategy and pollinators, and possible pests and diseases. The results will be applied to improve management practices.

To ultimately recover Hawaii's listed and other rare plant taxa, their habitat must be protected and managed for natural expansion of the current populations, as well as reintroduction of these taxa into portions of their former ranges. Maps of habitats believed to be important for recovery of listed plant species in Hawaii will be published by the U.S. Fish and Wildlife Service in the Recovery Plan for Multi-Island Plants (in press, 1998). The maps showing these habitat areas may be used by land owners and managers to identify priority areas for management and restoration and for wide-ranging planning purposes.

Finally, the recovery objectives should be refined and revised as new information becomes available.

RECOVERY

A. Objectives and Criteria

Objectives for stabilizing, downlisting, and delisting are provided for the Oahu plants. The order of tasks listed in the step-down outline and narrative does not necessarily designate the order in which these tasks should be implemented. Priorities for action and recommended time-frames are contained in the Implementation Schedule of this plan.

An endangered species is defined in Section 3 of the Endangered Species Act as any species which is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

For the purposes of this section, a population is defined as a discrete unit with sufficient distance between neighboring populations that the two are not affected by the same small-scale events (such as a landslide), and are not believed to be cross-pollinated. Mature individuals are defined as those either known or believed to be capable of reproduction. In general, long-lived perennials are those taxa that are either known or believed to have life spans greater than 10 years. Short-lived perennials are those known or believed to have life spans greater than one year but less than 10 years.

The long-lived perennials in this plan are: *Eugenia koolauensis, Hesperomannia arborescens, Hesperomannia arbuscula, Melicope lydgatei, Melicope saint-johnii, Pritchardia kaalae, Tetraplasandra gymnocarpa, and Urera kaalae.*

The short-lived perennials in this plan are: *Abutilon sandwicense*, *Alsinidendron obovatum*, *Alsinidendron trinerve*, *Chamaesyce celastroides* var. *kaenana*, *Chamaesyce deppeana, Chamaesyce herbstii, Chamaesyce kuwaleana*, *Chamaesyce rockii, Cyanea acuminata, Cyanea crispa, Cyanea grimesiana* ssp. *obatae*, *Cyanea humboldtiana, Cyanea koolauensis, Cyanea longiflora, Cyanea pinnatifida*, *Cyanea superba*, *Cyanea truncata, Cyrtandra crenata, Cyrtandra dentata, Cyrtandra polyantha, Cyrtandra st.-johnii, Cyrtandra subumbellata, Cyrtandra viridiflora, Delissea subcordata, Diellia falcata*, *Diellia unisora*, *Dubautia herbstobatae*, *Eragrostis fosbergii*, *Gardenia mannii, Gouania meyenii*, *Gouania vitifolia*, *Hedyotis degeneri*, *Hedyotis parvula*, *Labordia cyrtandrae*, *Lepidium arbuscula, Lipochaeta lobata* var. *leptophylla*, *Lipochaeta tenuifolia*, *Lobelia guadichaudii* ssp. *koolauensis*, *Lobelia monostachya, Lobelia niihauensis, Lobelia oahuensis*, *Myrsine juddii,* *Neraudia angulata, Nototrichium humile, Phlegmariurus nutans, Phyllostegia hirsuta, Phyllostegia kaalaensis, Phyllostegia mollis, Sanicula mariversa, Schiedea kaalae, Schiedea kealiae, Silene perlmanii, Stenogyne kanehoana, Tetramolopium filiforme, Tetramolopium lepidotum* ssp. *lepidotum, Trematolobelia singularis, Viola chamissoniana* ssp. *chamissoniana*, and *Viola oahuensis*.

Because we have only limited knowledge of the life history of each of these taxa with respect to specific requirements for their short-term and long-term survival, only tentative criteria for stabilizing, downlisting, and delisting are established here. These criteria were formulated based on recommendations by the Hawaii and Pacific Plants Recovery Coordinating Committee, as well as the International Union for Conservation of Nature and Natural Resources' (IUCN's) draft red list categories (Version 2.2) and the advice and recommendations of various biologists and knowledgeable individuals.

Additional information is needed about each of the Oahu cluster taxa so that more meaningful recovery objectives can be quantified.

Interim Objectives

The interim objective is to stabilize all existing populations of the Oahu Plant taxa. To be considered stable, each taxon must be managed to control threats (e.g., fenced) and be represented in an *ex situ* collection. In addition, a minimum total of three populations of each taxon should be documented on Oahu, and, if possible, at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 25 mature individuals per population for long-lived perennials and a minimum of 50 mature individuals per population for short-lived perennials.

Downlisting Objectives

For downlisting, a total of five to seven populations of each taxon should be documented on Oahu and at least one other island where they now occur or occurred historically. In certain cases, however, a particular taxon may be eligible for downlisting even if all five to seven of the populations are on only one island, provided all of the other recovery criteria have been met and the populations in question are widely distributed and secure enough that one might reasonably conclude that the taxon is not in danger of extinction throughout all or a significant part of its range.

Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials, and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of five consecutive years before downlisting is considered.

Delisting Objectives

A total of eight to ten populations of each taxon should be documented on Oahu and at least one other island where they now occur or occurred historically. As with downlisting, there may be certain cases in which a particular taxon may be eligible for delisting even if all eight to ten of the populations are on only one island, provided all of the other recovery criteria have been met and the populations in question are widely distributed and secure enough that one might reasonably conclude that the taxon is not in danger of extinction throughout all or a significant part of its range. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials and a minimum of 300 mature individuals per population for short-lived perennials. Each population should persist at this level for a minimum of five consecutive years.

B. Stepdown Outline

1. Protect habitat and control threats.
   11. Identify and map all extant wild populations.
   12. Delineate management units
   13. Ensure long-term protection of habitat.
   14. Identify and control threats.
       141. Control feral and wild ungulates.
            1411. Construct and maintain fencing.
            1412. Evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves.
       142. Control alien plants.
       143. Provide necessary fire protection.
       144. Control rodents, if necessary.
       145. Propagate and maintain genetic stock *ex situ*.
       146. Ensure availability of pollination vectors.
       147. Protect areas from human disturbance.
       148. Control insects, slugs, and snails, if necessary.
       149. Control all other identified threats.

2. Expand existing wild populations.
   21. Select populations for expansion.
   22. Prepare sites and plant.

3. Conduct essential research.
   31. Collect diagnostic data on crucial associated ecosystem components.
   32. Map alien vegetation.
   33. Study various aspects of growth.
   34. Study reproductive viability.
   35. Determine parameters of viable populations.
   36. Determine the effects of insects and/or diseases, and measures to control them.
   37. Identify and test potential biocontrol agents for host specificity and efficacy of control.
   38. Evaluate results and use in future management.

4. Develop and implement long-term monitoring programs for all species.

5. Reestablish wild populations within the historic range.
   51. Investigate feasibility and desirability of reintroduction.
   52. Develop and implement specific plans for reestablishment.

6. Validate recovery objectives.
   61. Determine number of populations and individuals needed for long-term survival.
   62. Refine/revise downlisting and delisting criteria.

C. Stepdown Narrative

1. Protect habitat and control threats.

The altered nature of the Oahu Plants Recovery Plan taxa's habitat, their precariously low numbers, and the severity of the threats acting upon the plants dictate that the highest-priority recovery actions, to be carried out immediately, must be aimed at protecting individuals and populations that currently exist in their native habitat and managing that habitat to control threats to the plants' survival. Currently, no extant wild individuals are known for four species (*Cyanea truncata*, *Cyrtandra crenata*, *Silene perlmanii*, and *Stenogyne kanehoana*), and surveys for these species should begin immediately. A monitoring program is essential to track the status of the populations, and to assess the effectiveness of threat management.

11. Identify and map all extant wild populations.

Protection of the extant populations will involve first locating all extant individuals, mapping their precise locations, and providing this information to the land managers. Priority should be given to the species for which there are no known individuals (*Cyanea truncata*, *Cyrtandra crenata*, *Silene perlmanii*, and *Stenogyne kanehoana*) and to *Cyrtandra polyantha*, which has not been observed in recent years.

Surveys in areas of all reported and possible occurrences of each taxon should be conducted. Occurrence data, including presence in or absence from previously reported sites (as well as site notes) and all relevant information for newly reported occurrences, should be carefully documented. Detailed site information (including directions, maps, global positioning system (GPS) data, and narratives) is recommended for each site.

12. Delineate management units.

Management units which, ideally, contain multiple populations of multiple species and can be managed under a single, coordinated, management plan should be identified for the 66 taxa in this recovery plan. These sites should include areas adequate for buffer zones and fire breaks and for expansion of existing populations and establishment of new populations for recovery. Similar areas around each newly discovered population of each taxon should be identified and targeted for protection and management. Management units can incorporate adjacent areas owned by different landowners. The Hawaii and Pacific Plant Recovery Coordinating Committee and Plant Recovery Teams may assist the USFWS, DOFAW, DOD, and other landowners and managers in identifying these management units.

13. Ensure long-term protection of habitat.

The protection of areas that contain these taxa is a primary concern. The protection currently provided to these taxa by various landowners should be continued and enhanced. This includes, but is not limited to, protection provided by Federal and State laws, regulations, and policies, and management plans and policies of Federal, State, and private landowners. Conservation agreements should be developed with private landowners, as needed, to provide technical and financial assistance for fencing, ungulate control, weeding, and other management actions.

Taxa on Federal lands are on portions of Schofield Barracks, Makua Military Reservation and Dillingham Military Reservation, under the jurisdiction of the U.S. Army, and Lualualai Naval Magazine, under the jurisdiction of the U.S. Navy. Additionally, the Army bears the responsibility for management of leased lands at Kahuku Training Area and Kawailoa Training Area, pending landowner approval. The Army and Navy should develop and implement Endangered Species Management Plans for areas that are not currently covered by a plan, and undergo section 7 consultations with the USFWS for any actions likely to affect the Oahu Plants Recovery Plan taxa on their lands.

The State of Hawaii should ensure that all departments within the State that are responsible for activities on lands harboring these plant taxa, such as land zoning, development projects, forestry projects, recreational programs, etc., are made aware of the presence of these listed plant taxa. In addition, the State should establish procedures to ensure that all State activities contemplated in the area are reviewed with respect to their potential impact on the listed plant taxa, with appropriate measures taken to minimize or preclude all negative impacts. DOFAW should develop and implement long-term management plans for the Oahu plant cluster taxa on their lands.

The remaining habitat is owned or managed by various private landowners. Steps should be taken to ensure that all such landowners are aware of the presence of the listed taxa on their lands and every effort should be made by DOFAW, DOD, and the USFWS to assist the landowners, as necessary, in developing and implementing long-term management plans for these lands.

14. Identify and control threats.

Each landowner of property on which these taxa occur should identify threats to the Oahu plant cluster taxa on their land, and take steps to protect the taxa from such threats. Many of the threats to these taxa have been well documented, while others need to be further defined. Additional threats may become apparent as additional populations are found. All of the threats to each population should be identified and prioritized. These threats include current and future development activities, feral ungulates, alien plants, fire, rodents, slugs and snails, human disturbance, a lack of pollinators, and, potentially, insects and disease.

Threat control plans should be developed for each area where the listed plants are found. When populations occupy habitat owned by different landowners, development of threat control plans should be carried out cooperatively, where possible. The delineation of management units (task #12) should allow for the cooperative management of logical groupings of populations. Threat control plans should be as all-encompassing as possible, possibly incorporating several management units into one overall plan for restoration and management of the habitats which support the 66 taxa identified in this recovery plan, along with other native components.

141. Control feral and wild ungulates.

The numbers of goats, pigs, cattle, and other introduced ungulates in the forests of Oahu and the other Hawaiian Islands are extensive. Controlling these ungulates to the point where they are no longer impacting native vegetation is absolutely imperative. Most of the taxa included in this plan cannot afford to wait many years for protection from ungulates. The most effective method currently known for providing immediate protection from introduced ungulates is fencing of discrete management units, accompanied by the removal of ungulates from within the fenced areas. Although this approach is costly, it does work, as demonstrated at Hawaii Volcanoes and Haleakala National Parks and elsewhere, and is a feasible solution for introduced ungulate control in Hawaii. Eradication of introduced animals including hunting, trapping, baiting, and snaring may sometimes be an option, given public support, and should also be considered.

1411. Construct and maintain fencing.

The most effective strategy will probably be a combination of methods, using short-term, small-scale fencing to protect populations under immediate threat from ungulates while longer-term, large-scale fencing projects are being undertaken. However, even "small" exclosures should be large enough to offset the negative impacts of the actual fencing and fence and site maintenance (e.g., scarification of fenceline and adjacent area and potential introduction of new pests into the area). As a general guideline, minimum-sized exclosures should have their perimeter located at least 50 meters (164 feet) distant from the nearest individual of the target species.

Fences should include, if possible, the target populations and a buffer area of good-quality, similar habitat, for potential replanting efforts (and/or native buffer habitat, if present, that is resistant to invasion of alien species). To reduce maintenance costs, fences should be constructed along ridgelines and tied into streamcourses at natural barriers (such as the tops of waterfalls) as much as possible.

Once the best method for fencing the management areas is determined, fencing and maintenance plans should begin as soon as possible. Fences should be impervious to all ungulates found in the area. Ongoing inspection and maintenance of fences are necessary to ensure the continued exclusion of ungulates from the fenced areas.

When each fence is completed, all ungulates should be removed from within.

While carrying out fencing and ungulate removal, managers must be aware of the potentially detrimental impacts of these management activities. Disturbance of soil and vegetation by managers can create open areas for new alien species invasions, and direct damage can result from inappropriate or careless activities.

Ongoing monitoring for ungulates within the large fenced areas is necessary to ensure their continued absence. Monitoring should also include determining the effects of the exclusion of ungulates, since their herbivory may have a more dramatic impact on invasive alien plants than on the endangered taxa. It is possible that without browsing by ungulates (until other management efforts can be devised and implemented), alien plants could quickly overwhelm some of the endangered taxa.

1412. Evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves.

Ideally, island-wide programs to eradicate introduced ungulates should be instigated and supported, where applicable. The State of Hawaii's Wildlife Plan recommends the removal of feral goats from Oahu (DLNR 1984). Fences are maintenance-intensive, cannot be built in all areas due to topography, and are not altogether a foolproof method of protecting habitats necessary for the perpetuation of the Oahu Plants Recovery Plan taxa. Ultimately, the eradication of introduced ungulate populations is the only way to completely eliminate these threats to the Oahu Plants Recovery Plan taxa. Such removal of introduced animals will also slow the degradation of watershed lands. However, public support of hunting is very fervent and the likelihood of acceptance of an ungulate eradication program is remote. Pursuing the establishment of game preserves throughout the State of Hawaii, where areas are set aside for hunting of game animals, should be a high priority within the State.

1413. Initiate ungulate control measures.

In many cases fencing is not possible due to dangerous working conditions during construction, limited efficacy due to topography, limited opportunity for subsequent management because of dangerous topography and remoteness. Furthermore, fence construction may have potentially detrimental impacts by disturbing soil and vegetation, thus creating open areas for new alien species invasions or directly damaging plants and animals due to inappropriate or careless activities. In such cases, other methods of eradication include traditional hunting, baited hunting, snaring, and poisoning. Also, hunting from helicopters is a highly effective method for introduced goat eradication, particularly for situations such as the steep cliffs in the Waianae Mountains. Ungulate eradication measures should always be carefully considered and used judiciously. Hunters and others who will be working in the habitat of the Oahu Plant Recovery Plan taxa should be apprised of the existence of the plants so that they do not inadvertently damage them.

142. Control alien plants.

One of the most important aspects of habitat management for the Oahu Plants Recovery Plan taxa is the control of invasive alien weeds. This may become even more important for some species if the removal of ungulates relieves grazing and browsing pressure on alien plants. Being aware of the potentially detrimental impact of management activities is important. Soil and vegetation disturbance by managers can create open areas for new alien species invasions, and direct damage can result from inappropriate or careless activities. Steps should always be taken to minimize these effects. Alien plants are believed to be a threat to all but one of the Oahu Plants Recovery Plan taxa, and a potential threat to one.

Effective weed control methods must be determined. Methods may include manual and chemical control. Weed control should be aggressively implemented in the vicinity of the Oahu Plants Recovery Plan taxa, particularly in and around fenced areas created to protect the plants from predators. Weed control should begin immediately for each population within the immediate vicinity of the existing plants and continue until control is achieved in the full management site. Follow-up visits to each site are necessary to ensure that weeds are permanently controlled. Weed control must be ongoing and sites should be monitored periodically to determine when additional intervention is necessary. Control efforts should be supervised by a botanist experienced in safe control methods to insure that crews do not compact soil, damage root systems or improperly apply herbicides. Also, care should be taken to protect associated native species, as well as the endangered species, during weed removal.

Many of the most significant weeds are widespread over large areas. The land areas presently occupied by these weeds may be too large for manual and chemical control to be practical. Release of biological control agents should be considered as a potential long term management tool.

Introduction of alien plants and other species to the State of Hawaii and between islands needs to be controlled to prevent further threats to the Oahu Plants Recovery Plan taxa and their habitats. To prevent the introduction of potentially detrimental alien species, support should be given to legislation, programs, or activities which limit the possibility of future introductions of alien species. The success of such programs or activities would contribute not only to the perpetuation of the endangered species in this plan, but to the quality of all native ecosystems and agricultural concerns in the State of Hawaii.

143. Provide necessary fire protection.

Protection from fire is critical to the survival of the taxa that occur in dry or mesic habitats. These plants are not well-adapted to survive fire, particularly those fires fed by unnatural buildup of fuel (such as that provided by the growth of alien grasses). In addition, many introduced plant species are better adapted to recovery after fires and often invade burned areas, permanently changing the habitat. Protection must be both local and on a larger scale to prevent fires from spreading to areas where the plants grow. Fire is a known threat to 22 of the 66 Oahu plant cluster taxa, and a possible threat to 14 additional taxa.

Plans to protect sites from fire are being developed at Schofield Barracks, Dillingham Military Reservation, Makua Military Reservation Kahuku Training Area, and Kawailoa Training Area and should be developed and implemented State-wide. Public education regarding the prevention and consequences of fires should be undertaken. "Fire-free" zones should be established, with hunters and other land users informed of the dangers of smoking and open flames in sensitive areas (i.e., any dry areas). Firebreaks with a minimum width of 6 meters (20 feet) should be constructed around fire-prone populations of the Oahu Plants Recovery Plan taxa wherever feasible. This minimum width is a guideline and may not be sufficient to protect populations from fire in especially dry conditions.

144. Control rats, if necessary.

Control of rats is needed in some cases to allow reproduction of endangered plant taxa. Measures need to be taken as necessary to control rodent damage to the endangered plants and their fruits and seeds to allow reproduction of the plants. Methods could include trapping, poisoning (including the use of the currently approved Diphacinone bait blocks and ultimately a more broad-scale method such as aerial dispersal of rodenticide), and/or the use of rodent barriers. Intensive rodent control over a period before and during fruit production is recommended for at least one season or until a good production season occurs, to have a viable crop of seeds for collection and *ex situ* propagation. Rats are current and potential threats to 24 of the 66 Oahu plant cluster species.

145. Propagate and maintain genetic stock *ex situ*.

Cultivated populations of each Oahu Plants Recovery Plan taxon should be maintained to establish pools of genetic resources for reintroduction to appropriate sites and to safeguard against loss of the material due to catastrophe in wild populations. However, it should be noted that cultivation of these plants is not a substitute for their preservation in the wild. Additionally, the existence of cultivated plants may reduce any demand for field-collected specimens of rare taxa by providing a propagated source of plants for which there might be a horticultural and/or research demand.

As broad a complement as possible of the existing genetic stock for each taxon should be preserved. For each identifiable population (either from extant sites or traceable, pure, cultivated material), genetic material from as many individuals as feasible should be collected. Collection methods and quantities of materials collected should be devised to have minimal impact on wild populations. All collected materials should be labeled accurately as to exact origin, collection date, etc.

Seeds of each taxon should be collected and entrusted to seed banks for long-term storage using the best available techniques for preservation. Seeds in long-term storage should be periodically tested for viability and recollected as necessary.

146. Ensure availability of pollination vectors.

Based on research findings, measures should be established to ensure that pollination vectors remain available to the Oahu Plants Recovery Plan taxa. If it is discovered that pollination vectors for certain taxa are in fact missing, necessary measures such as hand pollinating should be taken to compensate for these.

147. Protect areas from human disturbance.

Human disturbance is believed to be a current or potential threat to 36 of the 66 Oahu plant cluster species. Areas where these taxa grow should be protected as much as possible from hikers, vehicles, and other possibilities of direct human disturbance. Public awareness and education regarding these taxa should be fostered to help protect areas from human use. Plans are underway to ensure military training exercises avoid sensitive areas. Public education programs should be instigated, perhaps in conjunction with programs designed for other listed species. Other programs of public education regarding rare species and protection of native habitat should also be supported.

Signs designating sensitive environmental areas and/or research areas should be placed near sites where human contact may occur. "Kapu/No Trespassing" signs should prohibit entry to these areas. Such regulations should be strictly enforced by appropriate Federal and State agencies. If hiking is permitted, it is suggested that hikers must first be granted permission from the appropriate authority, which would inform hikers of the presence of sensitive environments and precautions that should be taken to avoid disturbance of such areas (e.g., cleaning of boots and clothing, the importance of staying on existing trails, etc.). Based on the specific situation, such signs may not be necessary for some populations that are in remote areas and/or areas not frequently visited. Signs may attract undue attention to these populations thereby exposing them to vandalism. Again, the decision regarding sign placement depends on the circumstances surrounding each population.

148. Control insects, slugs, and snails, if necessary.

Snails, slugs, and/or insects are known or potential threats to 29 of the 66 Oahu plans cluster species. Efforts to control these predators should be developed and implemented.

149. Control all other identified threats.

The need to control other threats may become apparent as more is learned about the Oahu Plants Recovery Plan taxa. New threats may also arise with further changes to natural habitats in Hawaii, such as introduction of new alien species. As new threats arise, management actions to reduce and/or eliminate their effects on the Oahu Plants should be implemented.

2. Expand existing wild populations.

It is hoped that by eliminating current threats through management, populations of the Oahu Plants Recovery Plan taxa will expand naturally. However, in certain instances, wild populations of the Oahu Plants Recovery Plan taxa may need to be augmented to reach down/delisting objectives. This should be done conservatively and only after careful consideration of all factors involved, particularly the threat of introducing detrimental organisms into the wild populations. Augmentation efforts should always be well-documented as to lineage and methods.

21. <u>Select populations for expansion</u>.

The need for expansion of current populations should be evaluated, and specific plans should be created for the augmentation of wild populations which need to be enhanced. These plans should include the following information: location of sites for expansion, determination of the plant material to be used, and the most appropriate methods to employ.

The goal of population augmentation is to allow a better chance for populations to survive in areas where they are known to occur naturally. All phases of augmentation operations should be well documented. Normally, progeny from plants of the same site/population should be used to augment a population to avoid contamination of the existing local gene pool with genetic material from other origins. Selected propagation materials must be free from pests, diseases, and pathogens that might be introduced to the new or nearby wild populations. This aspect is particularly critical since cultivated plants may have been grown in the presence of other pathogen-carrying plants, and nearby wild populations may have lower resistance to such introductions.

22. <u>Prepare sites and plant</u>.

Each selected site must be prepared and protected appropriately, including the building of exclosures and controlling alien species within those exclosures.

The selected material should then be planted. Care should be taken to match soils when transplanting already-started plants to avoid differences in water retention around the root areas (i.e., if surrounding soil is more absorptive, the soil directly around the roots could become overly dry and weaken or kill the newly transplanted specimen). Strict controls should be developed to ensure that no insects or diseases are introduced into the wild population as a result of planting.

Augmented populations should be monitored carefully (see Task #4). Ongoing maintenance of each site should occur after initial preparation and planting. The same projections and procedures regarding exclosures, ungulate removal, etc., should apply to new sites as have been recommended for existing sites (see task # 14).

3. Conduct essential research.

Research must be conducted into various aspects of the life history, habitat, pollinators, reproductive biology, symbionts, optimum requirements for growth, requirements for population viability, and control of threats to each of the Oahu Plants Recovery Plan taxa to better understand the requirements necessary for perpetuation of these plants. Such additional knowledge will allow more appropriate management and assessment techniques to be developed, and is needed to determine meaningful parameters for definition of specific recovery criteria for each taxon.

31. Collect diagnostic data on crucial associated ecosystem components.

Composition of flora and invertebrate, bird, and other fauna populations within each management area should be established to attempt to gain an understanding of any relationships between these organisms and the Oahu plants.

32. Map alien vegetation.

Periodic mapping of alien vegetation is recommended, using direct ground observations and aerial color and/or infrared photographs to make comparisons with previous maps and assess changes in alien vegetation where the Oahu cluster plants occur. Advantages of aerial techniques include: (1) the approach is not directly invasive into the sensitive habitat of the endangered plants; and, (2) large inaccessible areas may be monitored. Mapping would allow changes in distributions and abundance of alien plants to be followed so that appropriate management actions may be taken.

33. Study various aspects of growth.

Various aspects of the growth of each taxon need to be studied, including: growth and mortality of seedlings, growth of mature plants (including seasonal changes), optimum conditions and limiting factors, seasonal differences in temperature and light needs, water sources and requirements, and soil and nutrient requirements.

34. Study reproductive viability.

Factors affecting the reproductive viability of each of the Oahu plant taxa need to be determined, including: breeding systems, including self-compatibility, pollination vectors, and preferred conditions for flowering and seed set. This will allow development of the best management strategy for each taxon.

35. Determine parameters of viable populations.

Definitions of viable populations need to be established for each species. Such information could be used to more precisely determine criteria for consideration of downlisting or delisting. These parameters include: minimum numbers of individuals and populations needed for long-term survival, demographics, longevity, minimum range needed for long-term survival, genetic relationships and susceptibility to inbreeding depression, and dispersal potential.

36. Determine the effects of insects and/or diseases, and measures to control them.

The effects of harmful insects and disease on the Oahu Plants Recovery Plan taxa need to be determined to better manage the endangered plants and their habitats.

37. Identify and test potential biocontrol agents for host specificity and efficacy of control.

Many of the most significant weeds are widespread over large areas of land. For such weeds, manual and chemical control may be inefficient and ineffective due to time, cost, and logistics involved. Several of the weeds discussed in this plan have known natural enemies that have not yet been funded for evaluation as potential biological control agents in Hawaii. Examples are Christmas berry, strawberry guava, Koster's curse, and lantana (M. Isherwood, personal communication 1998). Potential biological control agents for these species as well as other particularly invasive weeds such as *Ardisia elliptica* should be identified and research conducted on their efficacy at controlling the target weed as well as host specificity.

38. Evaluate results and use in future management.

The results of the above studies should be evaluated and incorporated into the management process and development of scientifically credible recovery targets.

4. Develop and implement long-term monitoring programs for all species.

Populations of all the Oahu Plants Recovery Plan taxa should be monitored to ensure that current information is available regarding the status of each taxon. A detailed monitoring plan should be designed and implemented for each of the Oahu plants. Permanent plots around every occurrence of each taxon should be set up and mapped by size class to obtain baseline information regarding population size and local distribution patterns as well as the occurrence of other species in the vicinity. As new populations are discovered or established, they should be added to the monitoring program.

Individual plants may also be carefully tagged as appropriate for monitoring purposes. Data collection should include quantities and locations of all extant plants as well as any other relevant observations regarding phenology, habitat, or situation. Plots should be set up to allow point- and/or line-intercept monitoring methods as appropriate for each situation. Information such as changes in numbers of plants by size class, changes in vigor of individual plants, and changes or disturbances to the environment should be noted as appropriate and that data recorded.

5. Reestablish wild populations within the historic range.

If necessary to meet recovery objectives, populations should be reestablished in areas where they are known to have occurred historically, particularly if genetically uncontaminated, cultivated materials exist that are known to have originated from the historical site. The goal of reintroducing these taxa is to permanently re-establish viable populations in stable and secure conditions for their perpetuation.

51. <u>Investigate feasibility and desirability of reintroduction</u>.

For each taxon, appropriateness of reintroduction into wild situations should be assessed. Such reintroductions should be recommended conservatively and only after careful consideration of potential consequences. Genetic purity of populations is a prime concern, as are documentation of artificially established populations and the possibility of introducing pathogens to natural areas. Reintroduction efforts should always be well-documented as to lineage and methods.

52. <u>Develop and implement specific plans for reestablishment</u>.

Specific plans should be created for the reestablishment of wild populations when naturally occurring populations are not sufficient to reach recovery objectives. Plans for each taxon should include identification of reestablishment sites and plant materials to be used.

Once plans have been prepared, the reestablishment of populations should be implemented immediately. Ensure that selected materials are free from pests, diseases, and pathogens that might be introduced to the new or nearby wild populations. This aspect is particularly critical since cultivated plants may have been grown in the presence of other pathogen-carrying plants, and nearby wild populations may have lower resistance to such introductions.

If the sites chosen are outside the management units already established, they should be protected as discussed above.

Each selected site must be prepared appropriately, including the building of exclosures and control of exotic species therein, as necessary. The selected material should then be planted. Care should be taken regarding the matching of soils if transplanting already started plants due to differences in water retention around the root areas (i.e., if surrounding soil in the transplant area is more absorptive than the soil used to start the plant, the roots could be overly dried and the newly transplanted specimen could be weakened or could die).

Newly established populations should be monitored carefully (see Task #4). Ongoing maintenance of each site should occur after initial preparation and planting. The same projections and procedures regarding exclosures, feral animal removal, etc., as have been recommended for existing sites should also apply to new sites (see task # 14).

6. Validate recovery objectives.

The scientific validity of the recovery objectives should be reviewed and revised as appropriate as more information becomes available.

61. Determine number of populations and individuals needed for long-term survival.

For each of the Oahu Plants Recovery Plan taxa a determination of the number of populations and the number of individuals needed for long-term survival should be determined.

62. Refine/revise downlisting and delisting criteria.

Based on scientific information gathered during recovery efforts (e.g., data on viable population sizes, longevity, etc.), recovery criteria for each of the Oahu plant taxa should be revised to reflect new information. Until additional sound information is available, the criteria presented in this recovery plan should be used as the bases for downlisting and delisting.

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IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the Oahu Plants Recovery Plan. It is a *guide* for meeting the objectives discussed in Part II of this plan. This schedule indicates task priority, task numbers, task descriptions, duration of tasks, the entities responsible for committing funds, and lastly, estimated costs. The entities responsible for committing funds are not, necessarily, the entities that will actually carry out the tasks. When more than one entity is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the implementation schedule, when accomplished, should protect habitat for the species, stabilize the existing populations and increase the population sizes and numbers. Monetary needs for all parties involved are identified to reach this point, whenever feasible.

Priorities in Column 1 of the following implementation schedule are assigned as follows:

Priority 1	-	An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2	-	An action that must be taken to prevent a significant decline in species' population/habitat quality, or some other significant negative impact short of extinction.
Priority 3	-	All other actions necessary to provide for full recovery of the species.

Key to Acronyms Used in Implementation Schedule

BOT	—	Various Botanical Gardens (e.g., National Tropical Botanical Garden, Lyon Arboretum, Waimea Botanical Garden, etc.)
BRD	—	Biological Resources Division, U.S. Geological Survey
C	—	Continuing Task
DOD	—	Department of Defense
DOFAW	—	Division of Forestry and Wildlife, Hawaii Department of Land and Natural Resources
FWS	—	U.S. Fish & Wildlife Service, Pacific Island Ecoregion, Honolulu, Hawaii
FWS-LE	—	U.S. Fish and Wildlife Service, Law Enforcement, Honolulu, Hawaii
HDOA	—	State of Hawaii, Dept. of Agriculture
HPD	—	Hawaii Parks Division Department of Land and Natural Resources
O	—	Ongoing Task
OTHER	—	Various private landowners
TBD	—	To Be Determined
TNCH	—	The Nature Conservancy of Hawaii
USDA	—	U.S. Department of Agriculture
WS	—	U.S. Dept. of Agriculture, Wildlife Services

Recovery Plan Implementation Schedule for the Oahu Plants

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	Cost Estimates, by fiscal year, in thousands of dollars 1998	1999	2000	2001	2002
1	11	Identify and map all extant wild populations	5	*DOFAW	625	125	125	125	125	125
				FWS	300	60	60	60	60	60
				DOD	100	20	20	20	20	20
				TNCH	100	20	20	20	20	20
1	12	Delineate management units	3	*FWS	30		10	10	10	
				DOFAW	18		10	4	4	
				BRD	12		4	4	4	
				TNCH	12		4	4	4	
				DOD	12		4	4	4	
				OTHER	12		4	4	4	
1	13	Ensure long-term protection of habitat	3	*FWS	60	20	20	20		
				DOFAW	30	10	10	10		
				DOD	30	10	10	10		
				OTHER	30	10	10	10		
1	1411	Construct and maintain fencing	C	*DOFAW	4180		40	200	260	260
				DOD	3900		30	200	250	250
				FWS	3650		30	220	250	250
				TNCH	3650		30	220	250	250
				OTHER	TBD		TBD			

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	1998	1999	2000	2001	2002
						Cost Estimates, by fiscal year, in thousands of dollars				
1	1412	Evaluate the potential for controlling ungulates through eradication programs or establishment of game preserves	3	*DOFAW	30				10	10
				FWS	6				2	2
				DOD	6				2	2
				OTHER	TBD				TBD	
1	142	Control alien plants	C	*DOFAW	3450		65	235	235	235
				FWS	1480		65	65	65	65
				FWS-LE	400		20	20	20	20
				DOD	1870		65	95	95	95
				HDOA	300		15	15	15	15
				USDA	300		15	15	15	15
				HPD	200		10	10	10	10
				OTHER	TBD		TBD			
1	143	Provide necessary fire protection	C	*DOFAW	280			20	20	20
				FWS	280			20	20	20
				DOD	150			10	10	10
				HPD	114			6	6	6
1	144	Control rodents, if necessary	TBD	*DOFAW	0		TBD			
				DOD	0					
				WS	0					
1	145	Propagate and maintain genetic stock *ex situ*	O	*DOFAW	360	30	30	30	15	15
				FWS	360	30	30	30	15	15
				DOD	300	40	40	40	10	10
				BOT	300	40	40	40	10	10

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	1998	1999	2000	2001	2002
						Cost Estimates, by fiscal year, in thousands of dollars				
1	146	Ensure availability of natural pollination vectors	TBD	*DOFAW	0		TBD			
				FWS	0					
				DOD	0					
1	147	Protect areas from human disturbance	C	*DOFAW	800		40	40	40	40
				FWS	800		40	40	40	40
				DOD	800		40	40	40	40
				OTHER	200		10	10	10	10
				HPD	120		6	6	6	6
1	148	Control insects, slugs, and snails, if necessary,	TBD	*DOFAW	0		TBD			
				FWS	0					
1	149	Control all other identified threats	C	*DOFAW	1200		60	60	60	60
				FWS	1200		60	60	60	60
				DOD	1200		60	60	60	60
				OTHER	200		10	10	10	10
		NEED 1 (Protect Habitat and Control Threats)			33457	415	1162	2122	2166	2136
1	21	Select populations for expansion	5	*DOFAW	150		30	30	30	30
				FWS	150		30	30	30	30
				BRD	150		30	30	30	30
				DOD	150		30	30	30	30
				OTHER	150		30	30	30	30
1	22	Prepare sites and plant	TBD	*DOFAW	0		TBD			

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	Cost Estimates, by fiscal year, in thousands of dollars 1998	1999	2000	2001	2002
				FWS	0		TBD			
				DOD	0		TBD			
				OTHER	0		TBD			
		NEED 2 (Expand Existing Wild Populations)			750	0	150	150	150	150
2	31	Collect diagnostic data on crucial associated ecosystem components	10	*BRD	1100		110	110	110	110
				DOFAW	650		65	65	65	65
				FWS	200		20	20	20	20
				TNCH	200		20	20	20	20
2	32	Map alien vegetation	C	*DOFAW	240		30	30	10	10
				FWS	112		20	20	4	4
				DOD	112		20	20	4	4
				BRD	112		20	20	4	4
				TNCH	112		20	20	4	4
2	33	Study various aspects of growth	10	*BRD	600		60	60	60	60
				FWS	600		60	60	60	60
				DOFAW	600		60	60	60	60
2	34	Study reproductive viability	10	*BRD	600		60	60	60	60
				FWS	600		60	60	60	60
				DOFAW	600		60	60	60	60
2	35	Determine parameters of viable populations	10	*BRD	600		60	60	60	60
				FWS	600		60	60	60	60

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	1998	1999	2000	2001	2002
						Cost Estimates, by fiscal year, in thousands of dollars				
				DOFAW	600		60	60	60	60
	36	Determine the effects of insects and/or diseases, and measures to control them		DOFAW	TBD		TBD			
				FWS	TBD		TBD			
				HDOA	TBD		TBD			
2	37	Identify and test potential biocontrol agents for host specificity and efficacy of control	TBD	HDOA	TBD					
2	38	Evaluate results and use in future management	TBD	*DOFAW	TBD		TBD			
				BRD	TBD		TBD			
				FWS	TBD		TBD			
				WS	TBD		TBD			
		NEED 3 (Conduct Essential Research)			8238	0	865	865	781	781
2	4	Develop and implement long-term monitoring programs for all species	C	*DOFAW	450		45	45	20	20
				FWS	240		30	30	10	10
				DOD	240		30	30	10	10
				BOT	240		30	30	10	10
				BRD	240		30	30	10	10
		NEED 4 (Develop and maintain monitoring plans)			1410		165	165	60	60
2	51	Investigate feasibility and desirability of reintroduction	5	*DOFAW	100			20	20	20
				FWS	50			10	10	10
				BRD	50			10	10	10

Priority #	Task #	Task Description	Task Duration	Responsible Party	Total Cost	Cost Estimates, by fiscal year, in thousands of dollars 1998	1999	2000	2001	2002
				BRD	50			10	10	10
2	52	Develop and implement specific plans for reestablishment	TBD	*DOFAW	0	TBD				
				FWS	0	TBD				
				BRD	0	TBD				
				DOD	0	TBD				
				OTHER	0	TBD				
		NEED 5 (Reestablish populations within historic range)			200	0	0	40	40	40
3	61	Determine number of individuals and populations for long-term survival	3	*BRD	60					
				FWS	60					
				DOFAW	60					
3	63	Refine/revise downlisting and delisting criteria	3	*FWS	60					
				DOFAW	60					
		NEED 6 (Validate Recovery Objectives)			300	0	0	0	0	0
		TOTAL COST			44355	415	2342	3342	3197	3167

APPENDIX A

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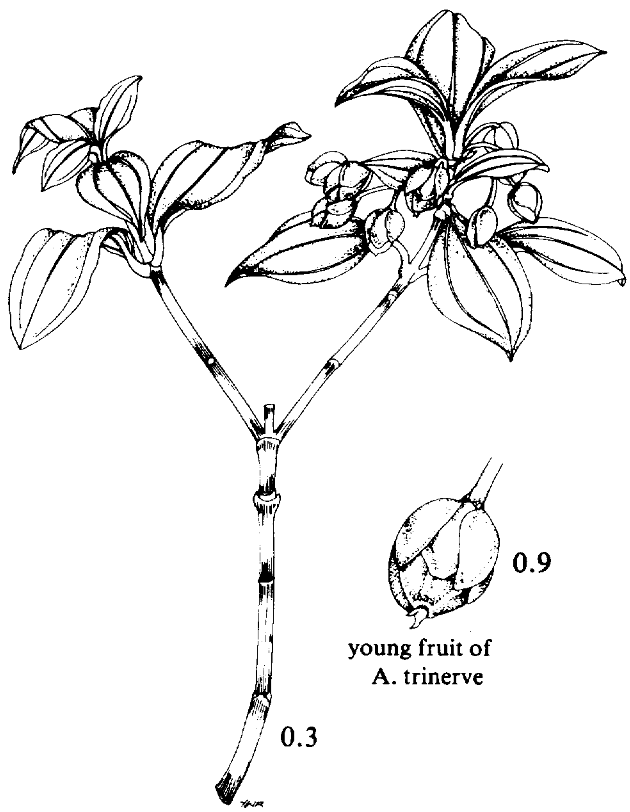
APPENDIX B

LINE DRAWINGS OF PLANTS

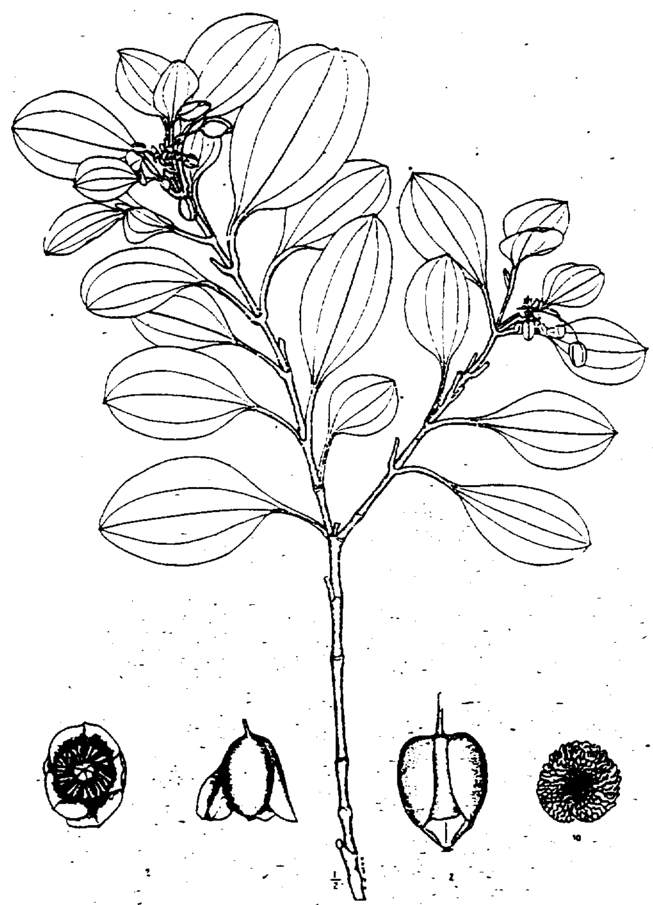
No line drawings were available for the following species:

Chamaesyce celastroides var. *kaenana*
Chamaesyce deppeana
Chamaesyce herbstii
Chamaesyce kuwaleana
Cyanea crispa
Cyrtandra crenata
Diellia unisora
Dubautia herbstobatae
Hedyotis degeneri
Hedyotis parvula
Lipochaeta lobata var. *leptophylla*
Lobelia monostachya
Lobelia oahuensis
Melicope lydgatei
Melicope saint-johnii
Myrsine juddii
Phyllostegia kaalaensis
Pritchardia kaalae
Phyllostegia mollis
Silene perlmanii
Tetraplasandra gymnocarpa

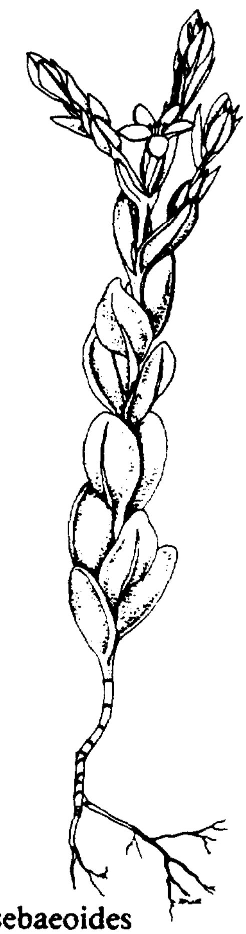
Line drawing of *Albutilon sandwicense* from Wagner et al. (1990).



Line drawing of *Alsinidendron obovatum* from Wagner et al. (1990).

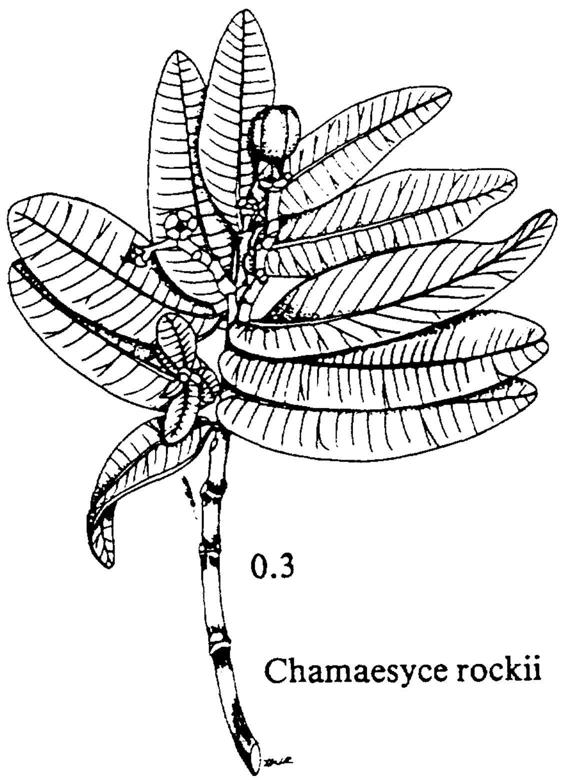


Line drawing of *Alsinidendron trinerve* from Degener (1937a).



Centaurium sebaeoides

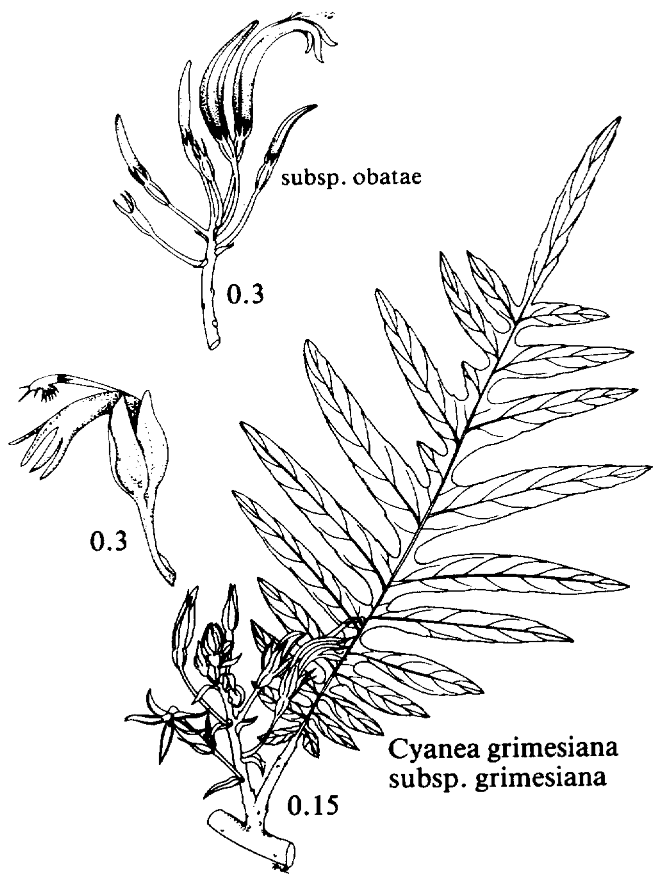
Line drawing of *Centaurium sebaeoides* from Wagner et al. (1990).



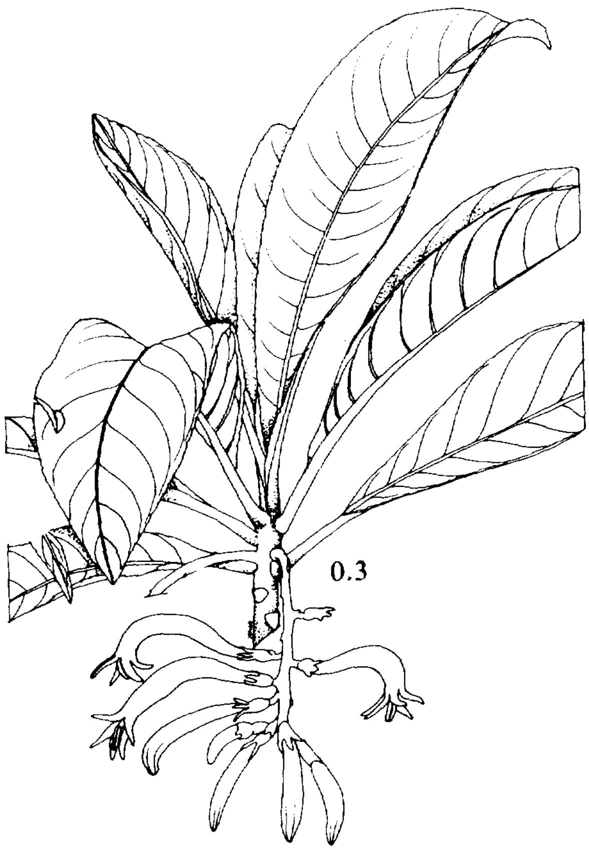
Line drawing of *Chamaesyce rockii* from Wagner et al. (1990).

Cyanea acuminata

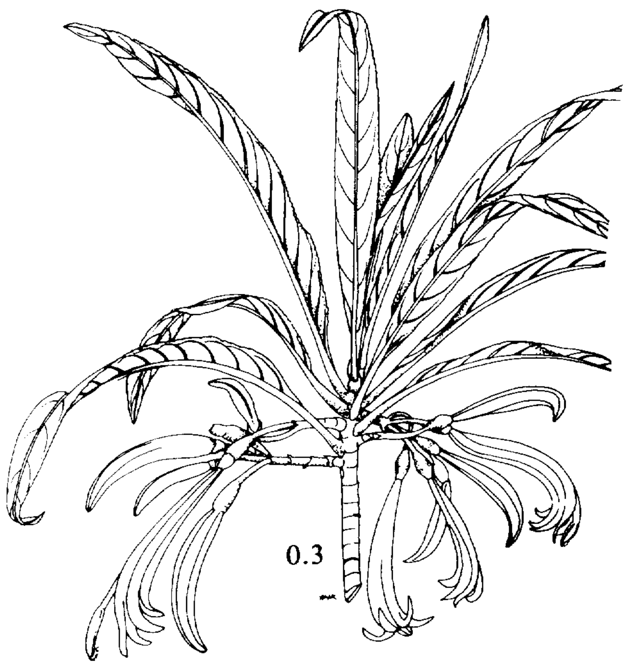
Line drawing of *Cyanea acuminata* from Wagner et al. (1990).



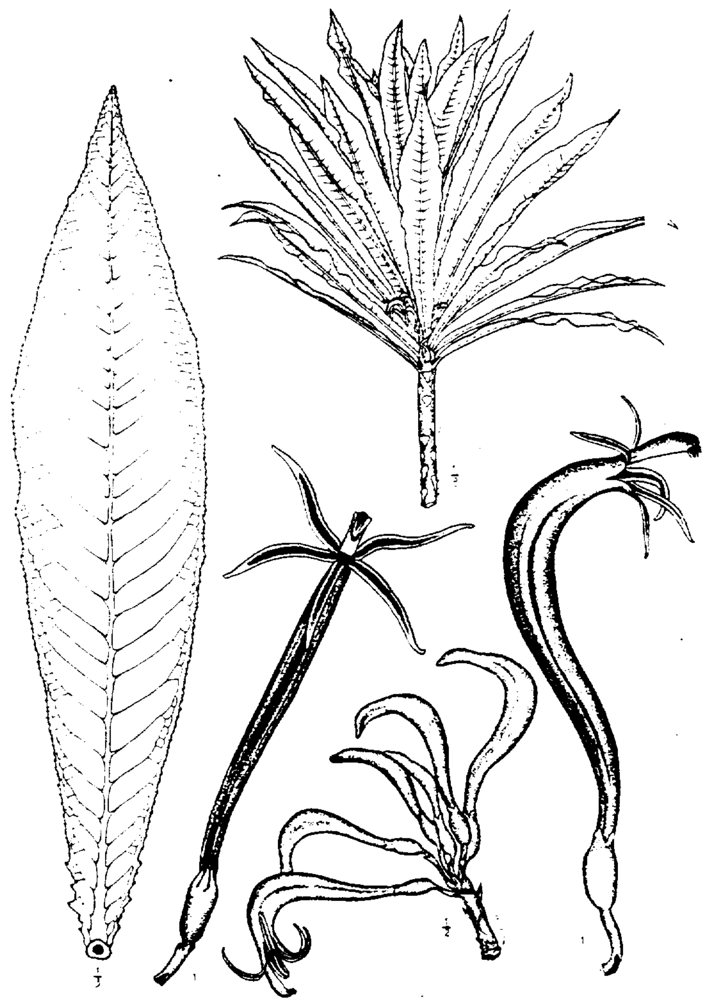
Line drawing of *Cyanea grimesiana* ssp. *obatae* from Wagner et al. (1990).



Line drawing of *Cyanea humboldtiana* from Wagner et al. (1990).



Line drawing of *Cyanea koolauensis* from Wagner et al. (1990).

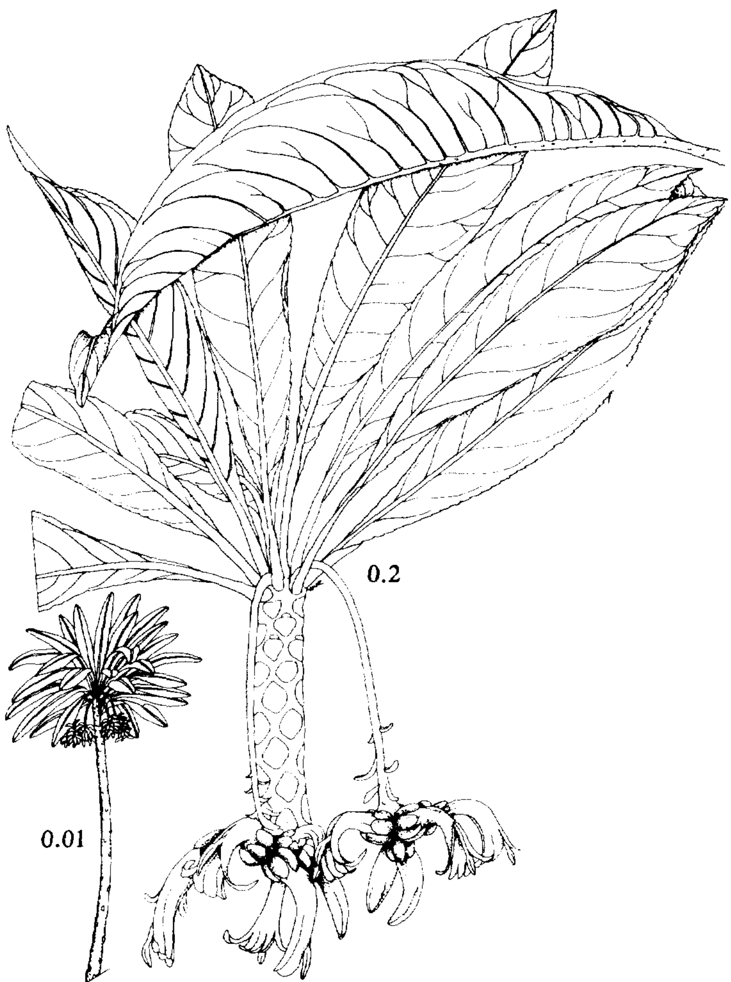


Line drawing of *Cyanea longiflora* from Degener (1932b).

Cyanea pinnatifida

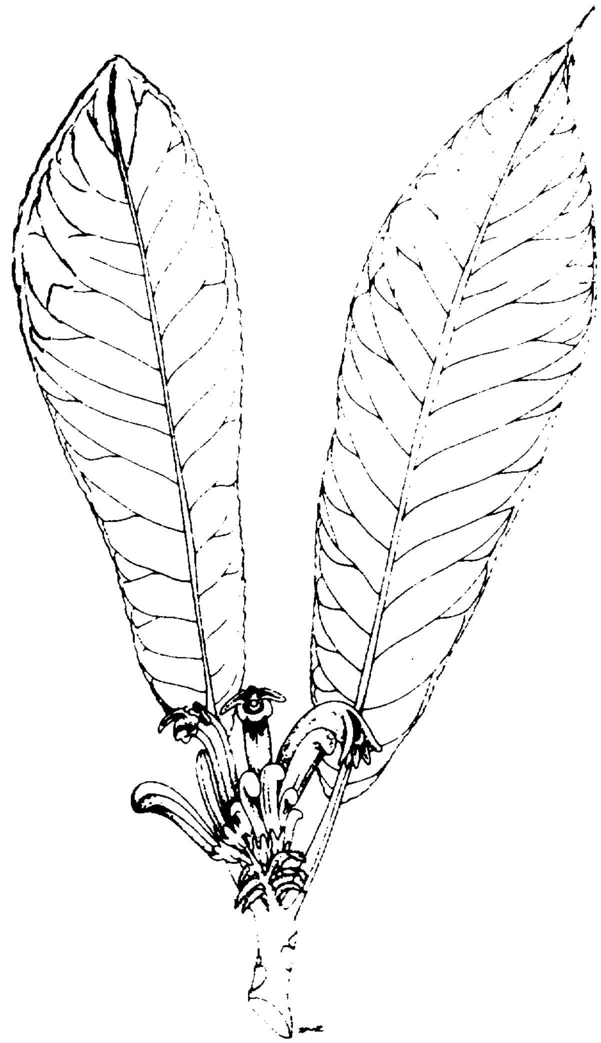
Line drawing of *Cyanea pinnatifida* from Wagner et al. (1990).

Line drawing of *Cyanea st.-johnii* from Wagner et al. (1990).



Cyanea superba subsp. superba

Line drawing of *Cyanea superba* from Wagner et al. (1990).



Line drawing of *Cyanea truncata* from Wagner et al. (1990).

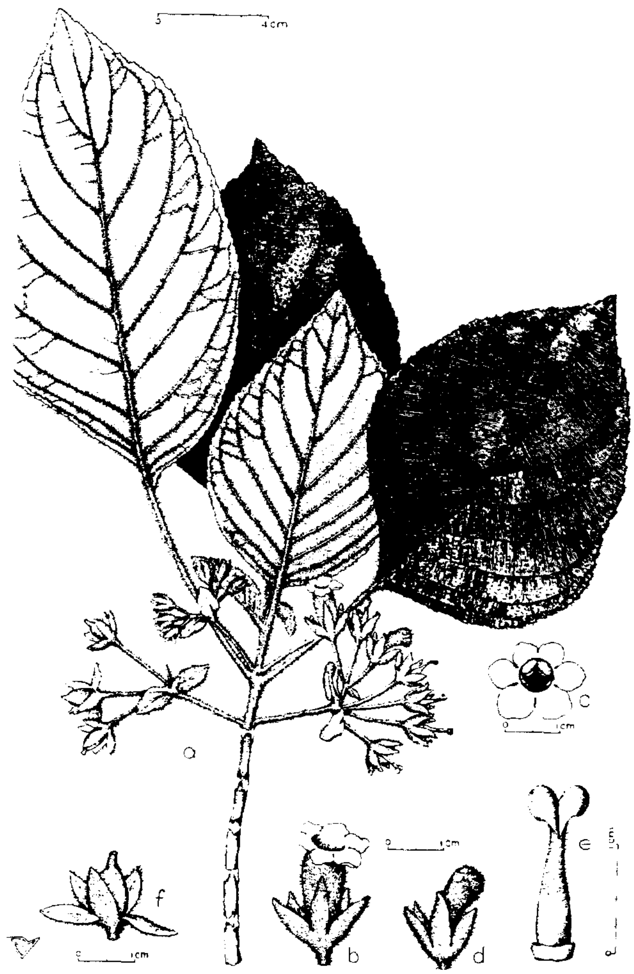
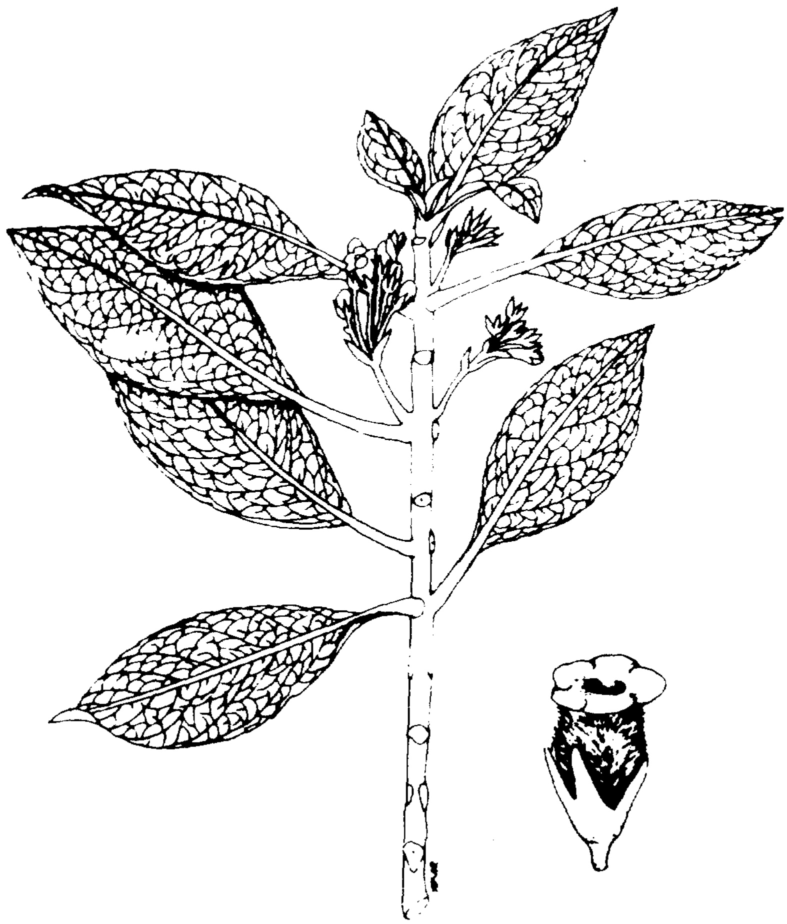
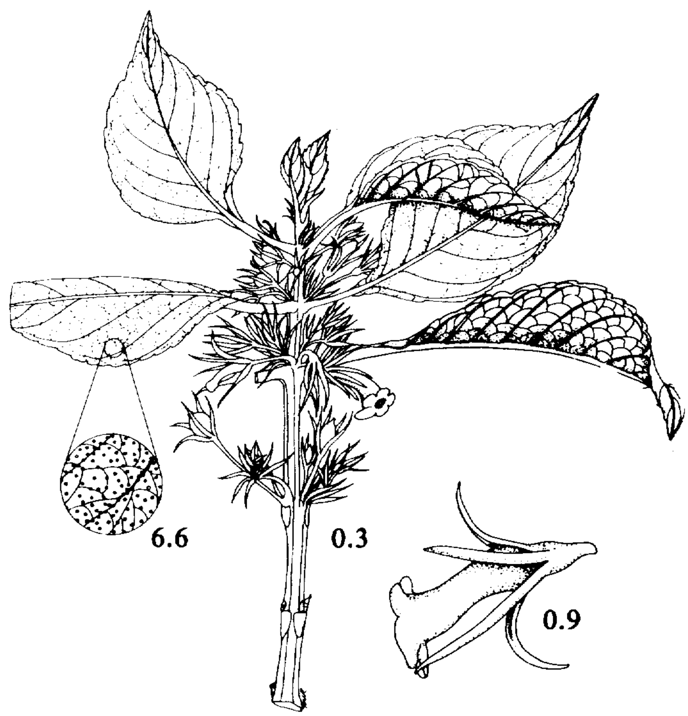


FIGURE 32.—*Cyrtandra dentata*: **a**, habit, × ½; **b**, **c**, flower, × 1; **d**, bud, × 1; **e**, pistil, × 2; **f**, fruit, × 1. Waiola Valley, Kawailoa, St. John 21,364, holotype (Bishop Mus.).

Line drawing of *Cyrtandra dentata* from St. John (1966).

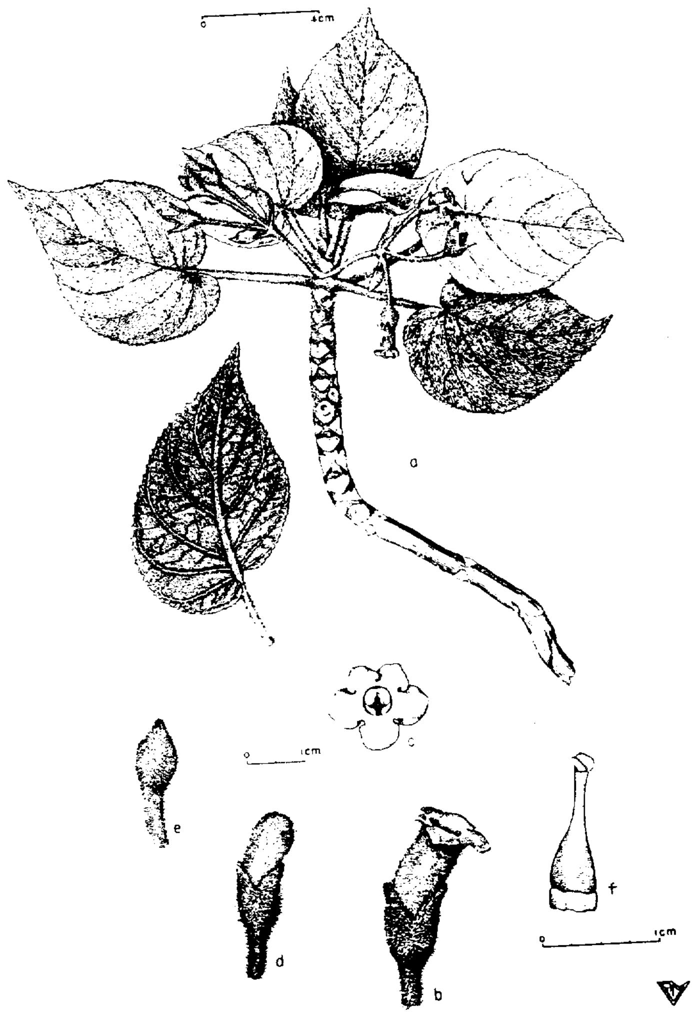


Line drawing of *Cyrtandra polyantha* from Wagner et al. (1990).

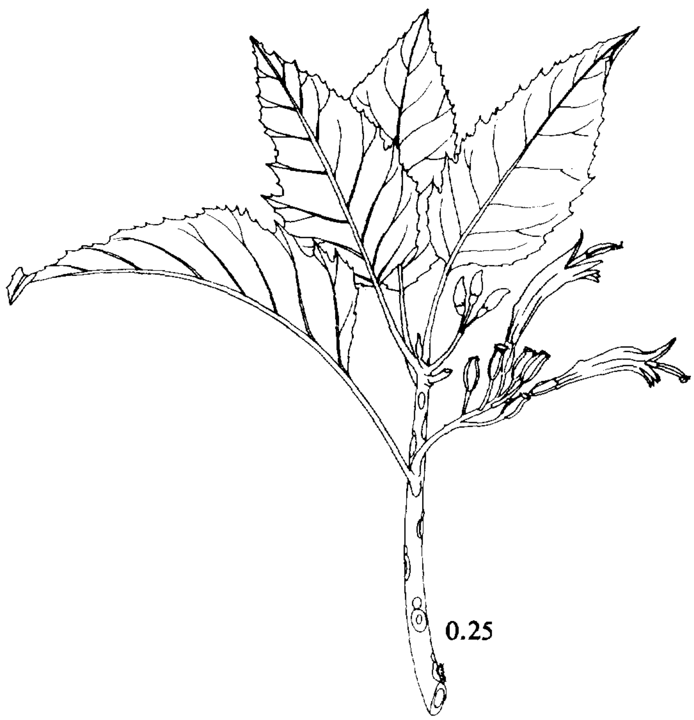


Cyrtandra subumbellata

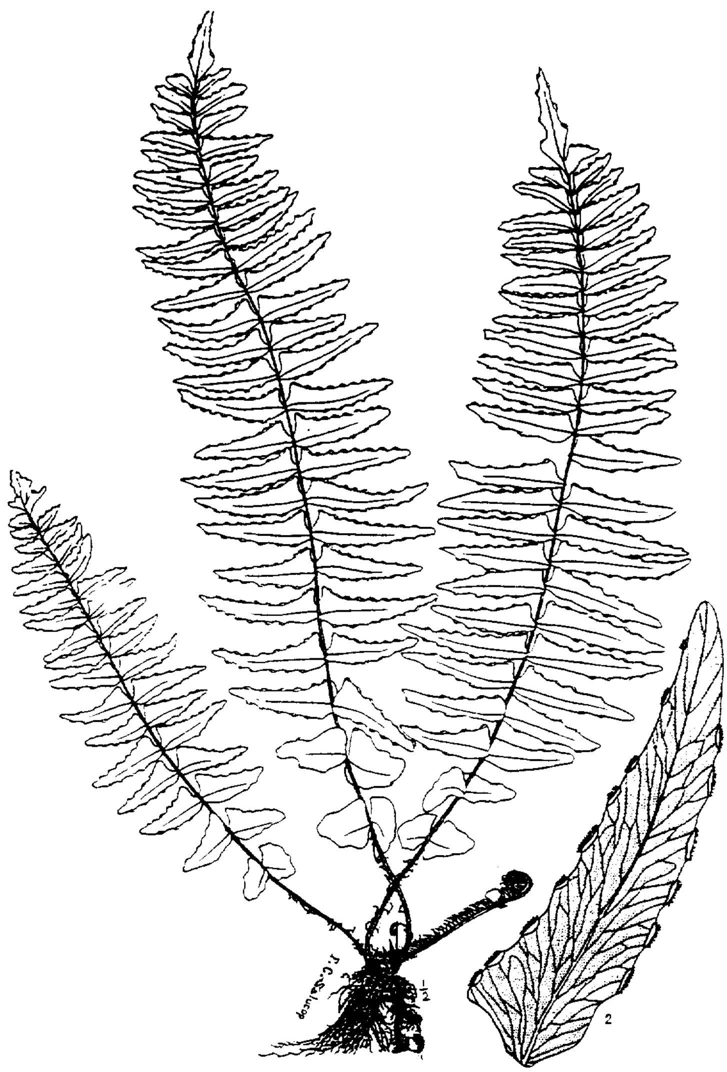
Line drawing of *Cyrtandra subumbellata* from Wagner et al. (1990).



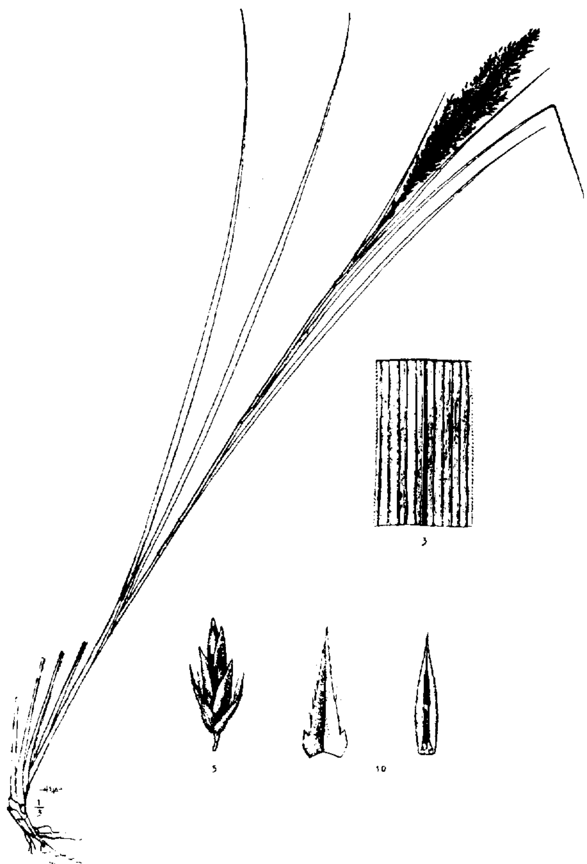
Line drawing of *Cyrtandra viridiflora* from Wagner et al. (1990).



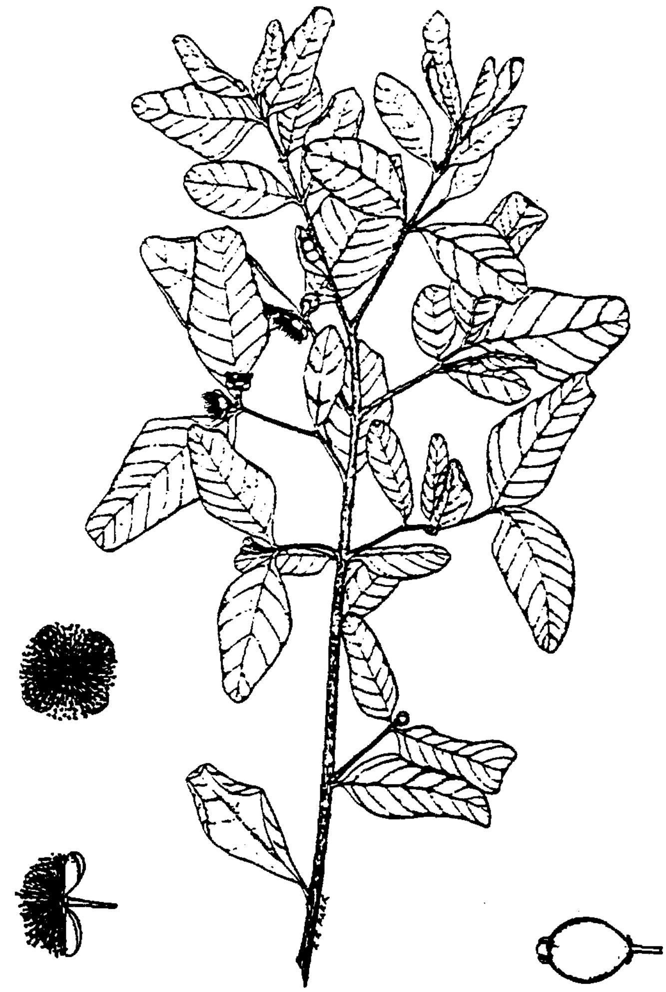
Line drawing of *Delissea subcordata* from Wagner et al. (1990).



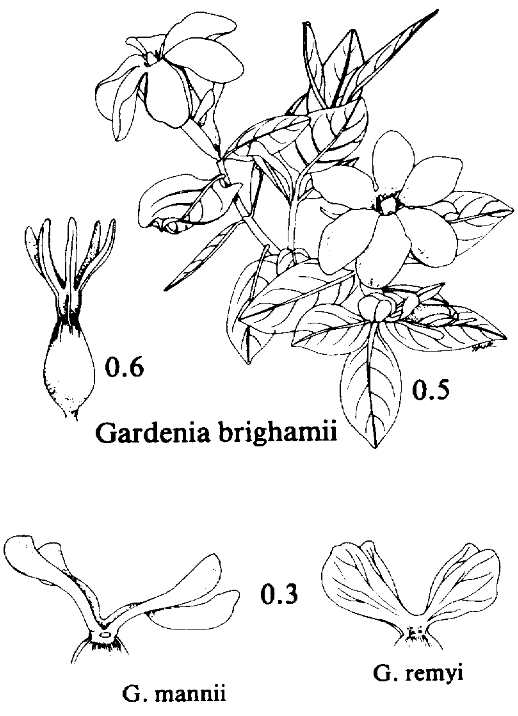
Line drawing of *Diellia falcata* from Wagner et al. (1990).



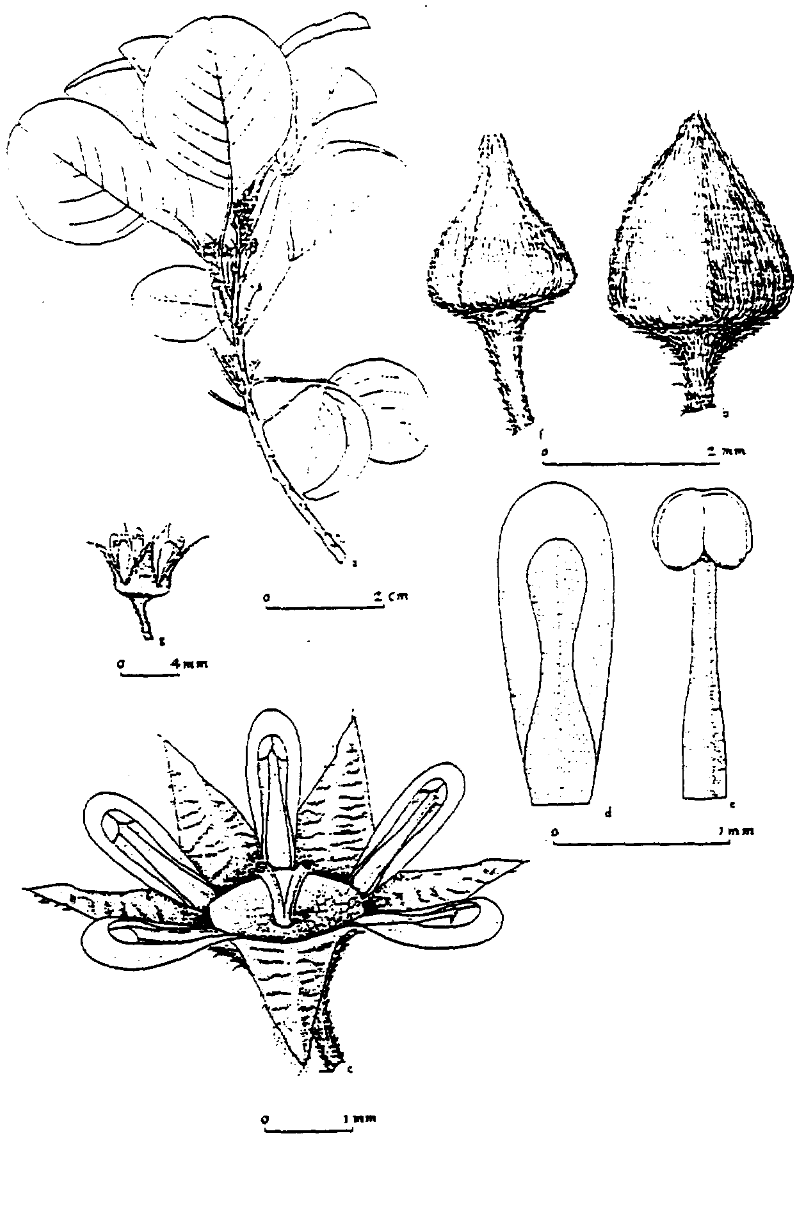
Line drawing of *Eragrostis fosbergii* from Degener and Whitney (1940).



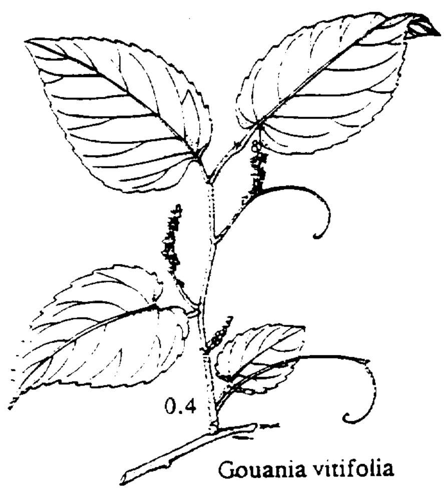
Line drawing of *Eugenia koolauensis* from Degener (1932a).



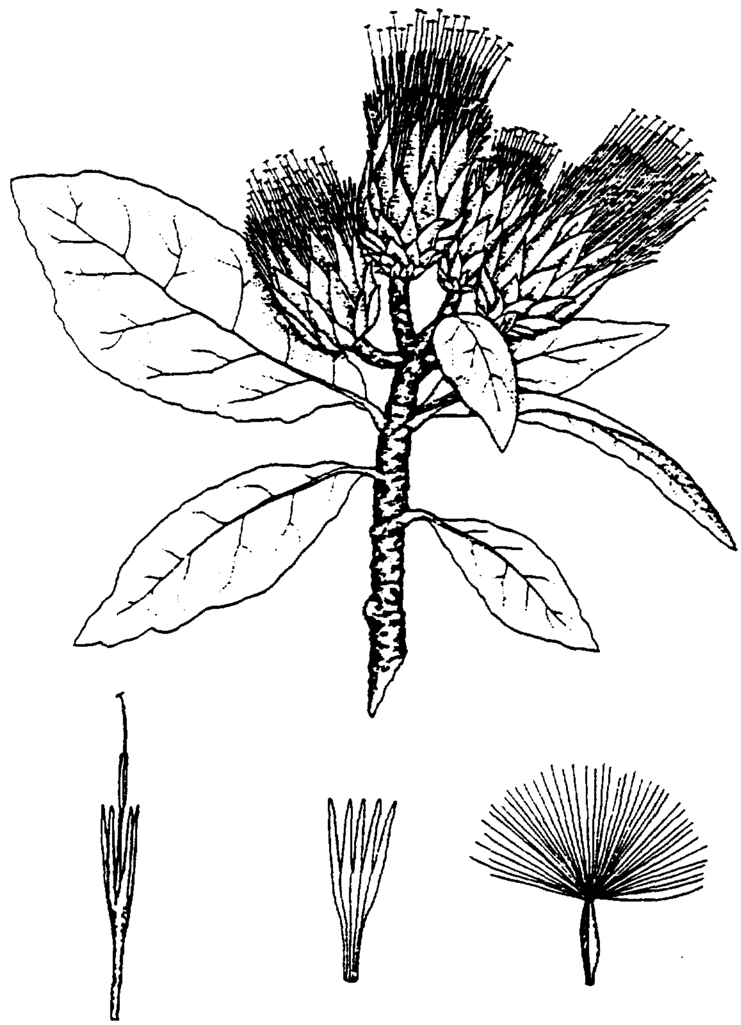
Line drawing of *Gardenia mannii* from Wagner et al. (1990).



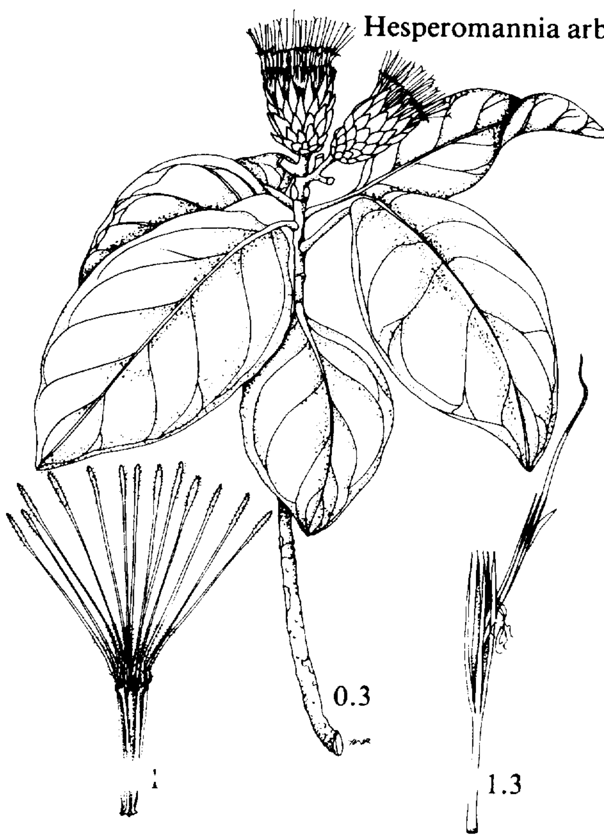
Line drawing of *Gouania meyenii* from St. John (1969).



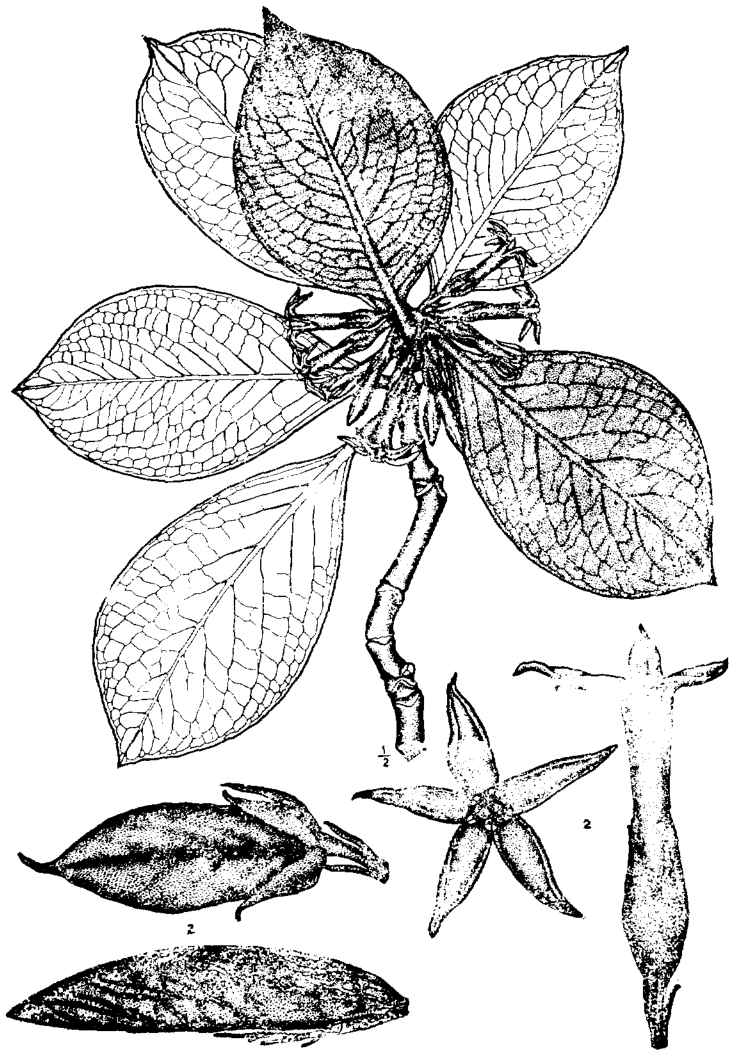
Line drawing of *Gouania vitifolia* from Wagner et al. (1990).



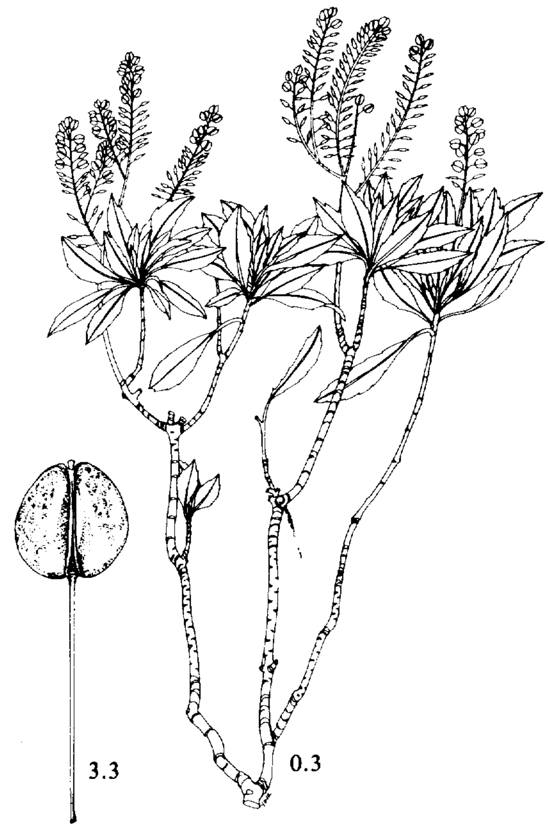
Line drawing of *Hesperomannia arborescens* from USFWS (1995)..



Line drawing of *Hesperomannia arbuscula* from Wagner et al. (1990).



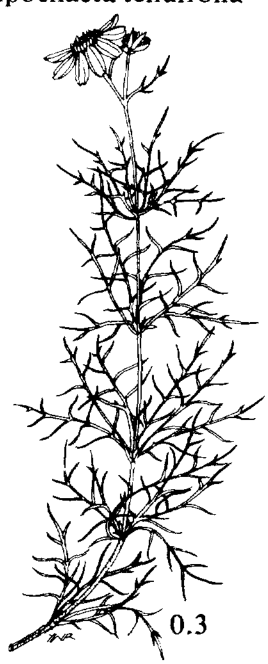
Line drawing of *Labordia cyrtandrae* from Degener and Degener (1957)



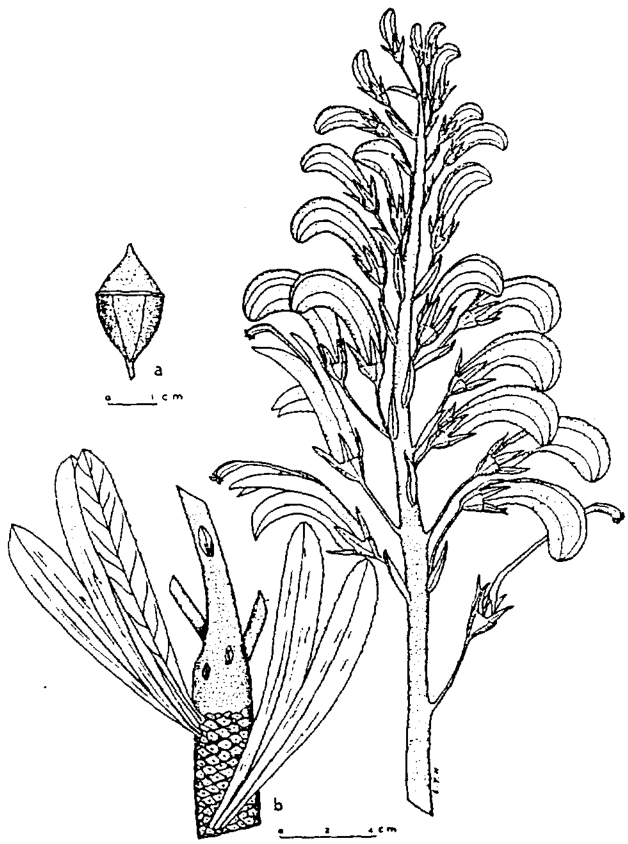
Lepidium arbuscula

Line drawing of *Lepidium arbuscula* from Wagner et al. (1990).

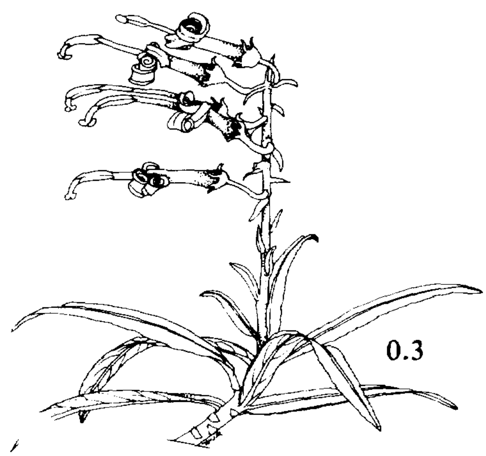
Lipochaeta tenuifolia



Line drawing of *Lipochaeta tenuifolia* from Wagner et al. (1990).

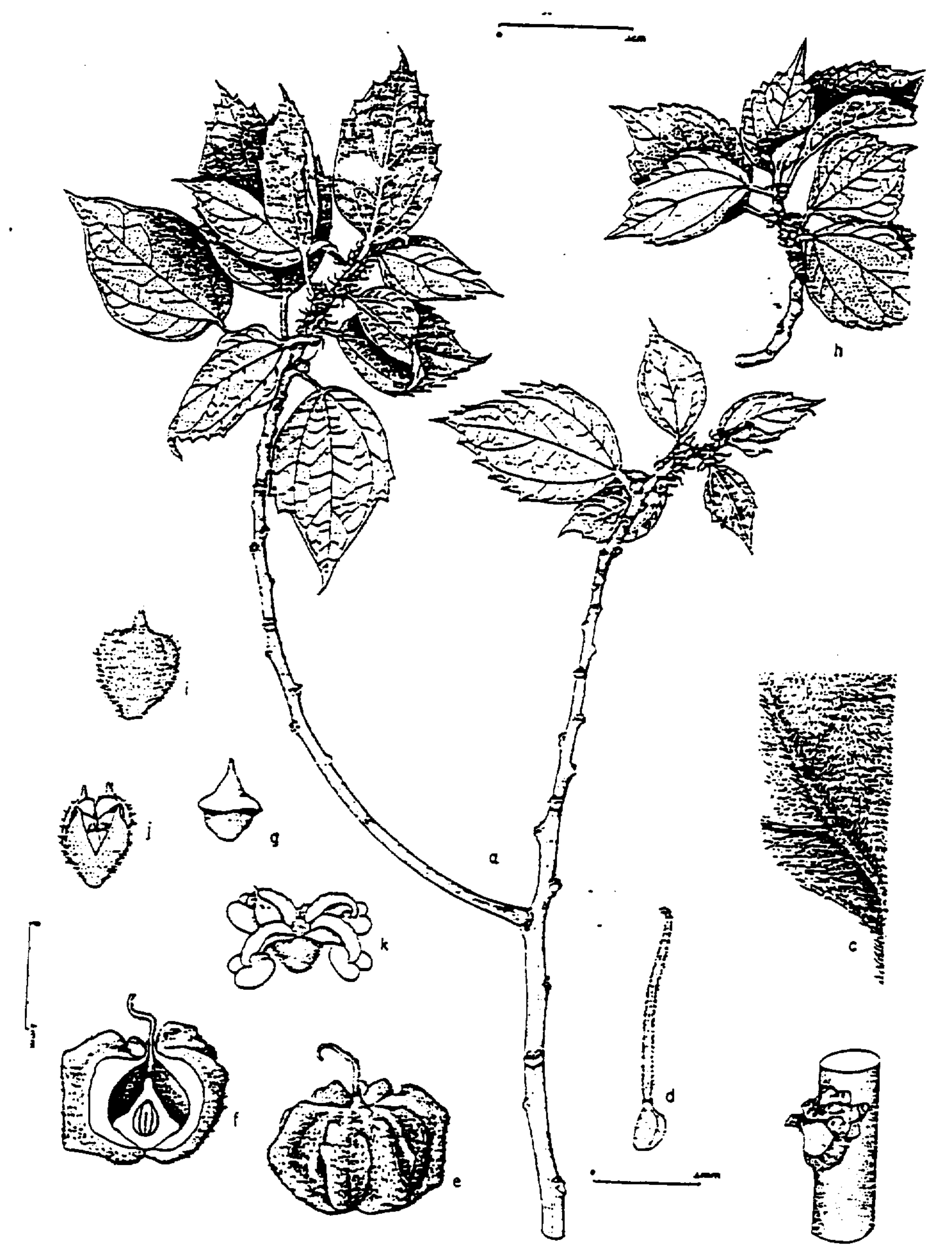


Line drawing of *Lobelia gaudichaudii* ssp. *koolauensis* from Fosberg and Hosaka (1938).

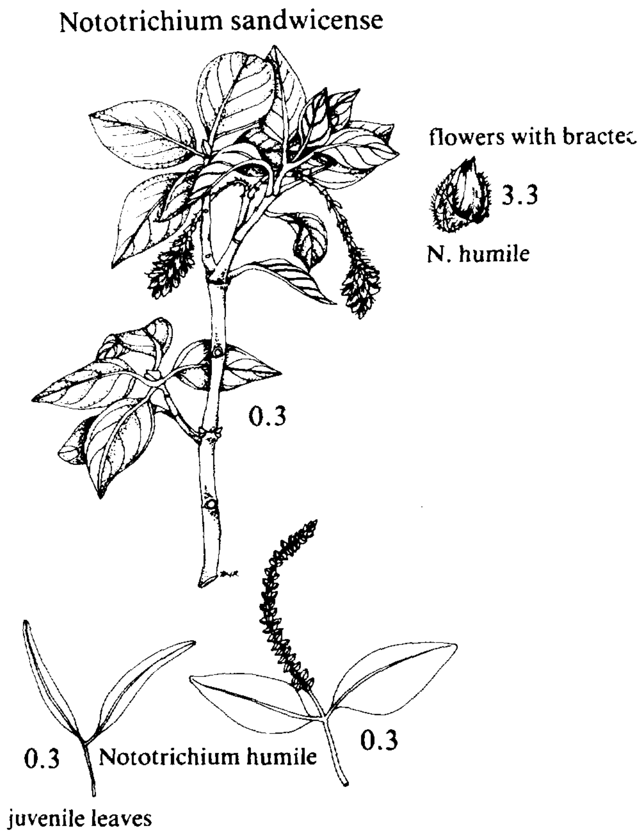


Lobelia niihauensis

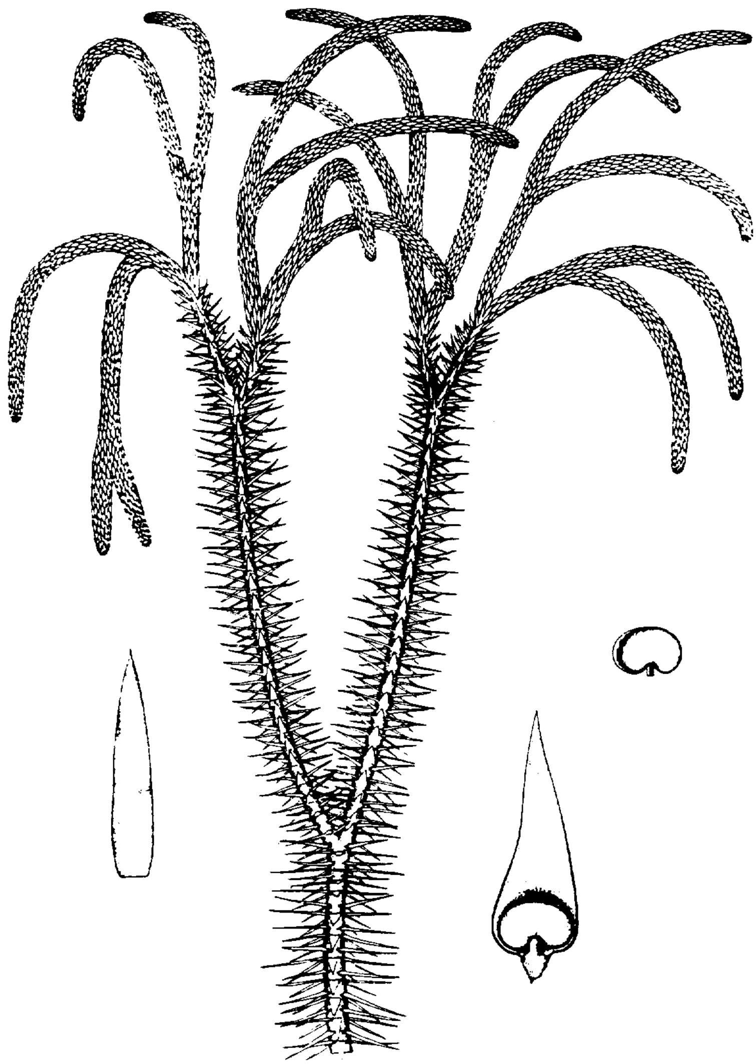
Line drawing of *Lobelia niihauensis* from Wagner et al. (1990).



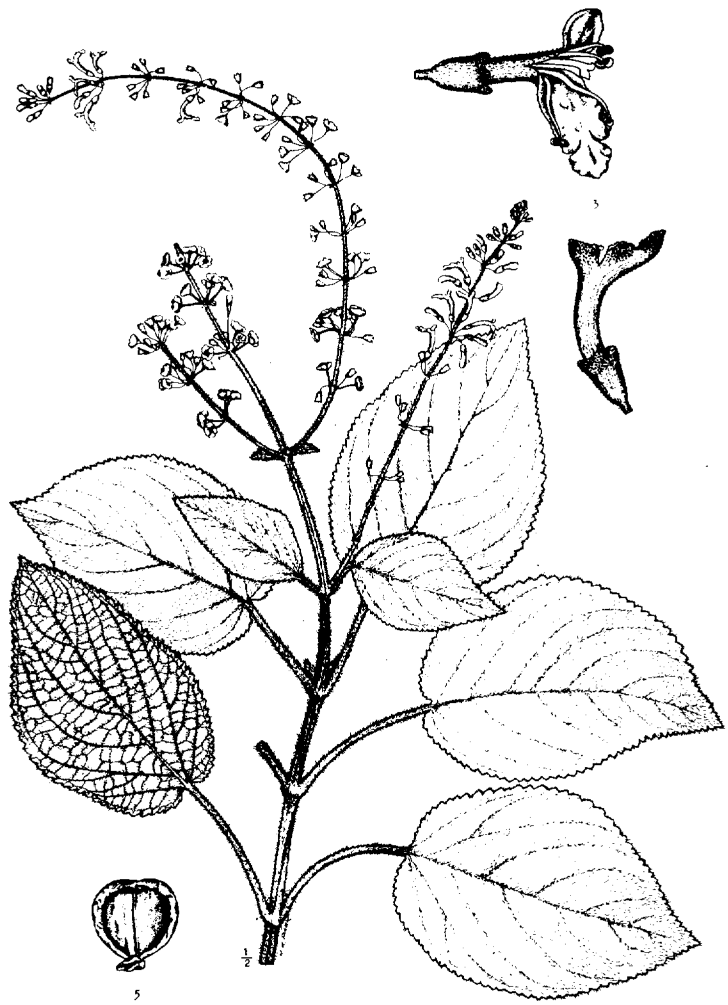
Line drawing of *Neraudia angulata* from USFWS (1995).



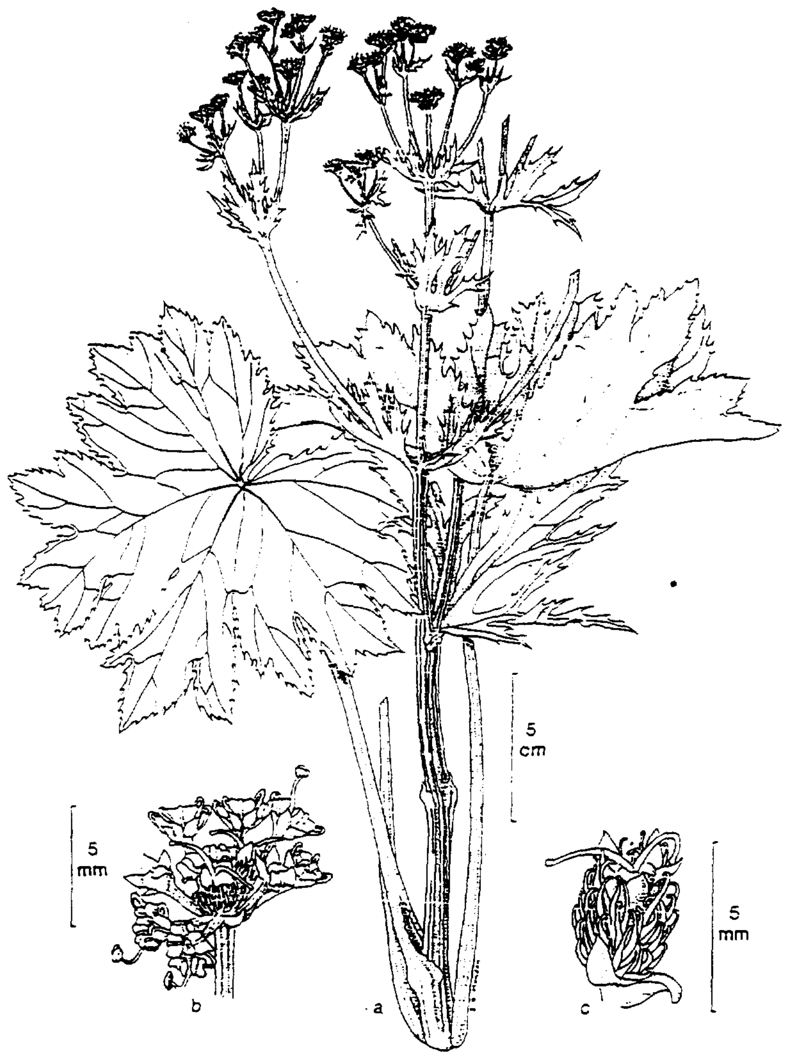
Line drawing of *Nototrichium humile* from Wagner et al. (1990).



Line drawing of *Phlegmariurus nutans* from Degener (1934a).

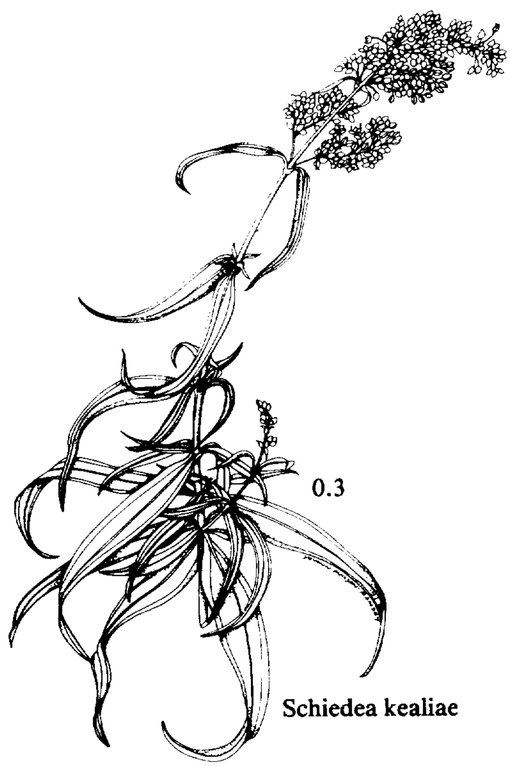


Line drawing of *Phyllostegia hirsuta* from Degener (1934b).



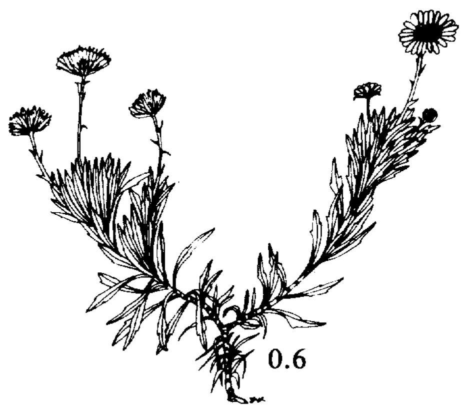
Line drawing of *Sanicula mariversa* from Nagata and Gon (1987).

Line drawing of *Schiedea kaalae* from Wagner et al. (1990).



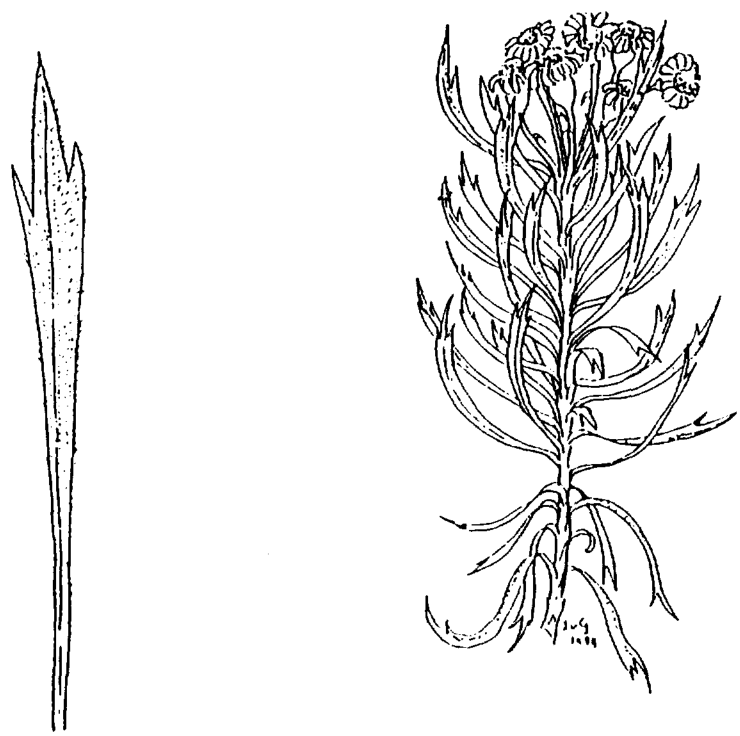
Line drawing of *Schiedea kealiae* from Wagner et al. (1990).

Line drawing of *Stenogyne kanehoana* from Wagner et al. (1990).

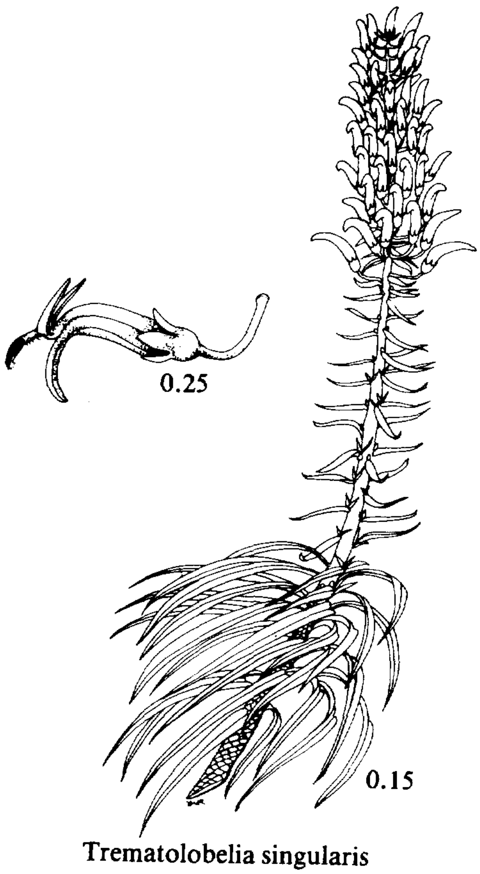


Tetramolopium filiforme var. polyphyllum

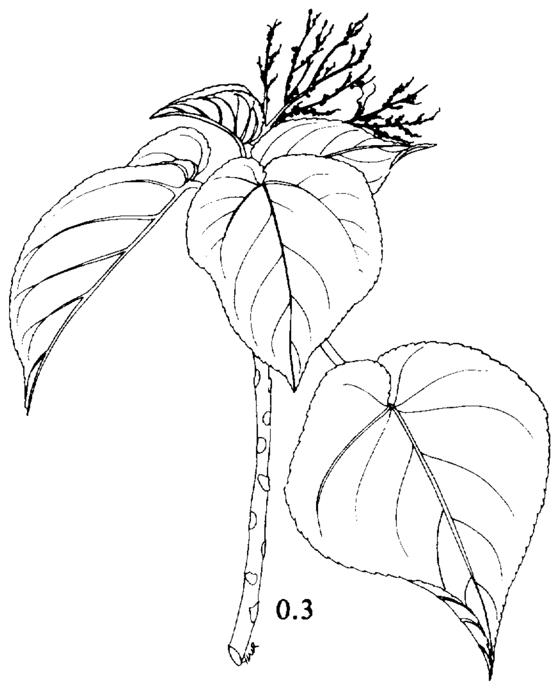
Line drawing of *Tetramolopium filiforme* from Wagner et al. (1990).



Line drawing of *Tetramolopium lepidotum* ssp. *lepidotum* from Lowrey (1986).



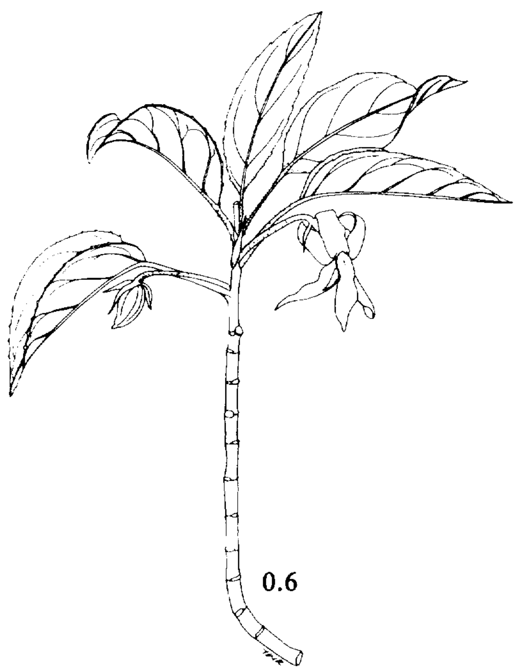
Line drawing of *Trematalobelia singularis* from Wagner et al. (1990).



Urera kaalae

Line drawing of *Urera kaalae* from Wagner et al. (1990).

Line drawing of *Viola chamissoniana* ssp. *chamissoniana* from Degener (1952).



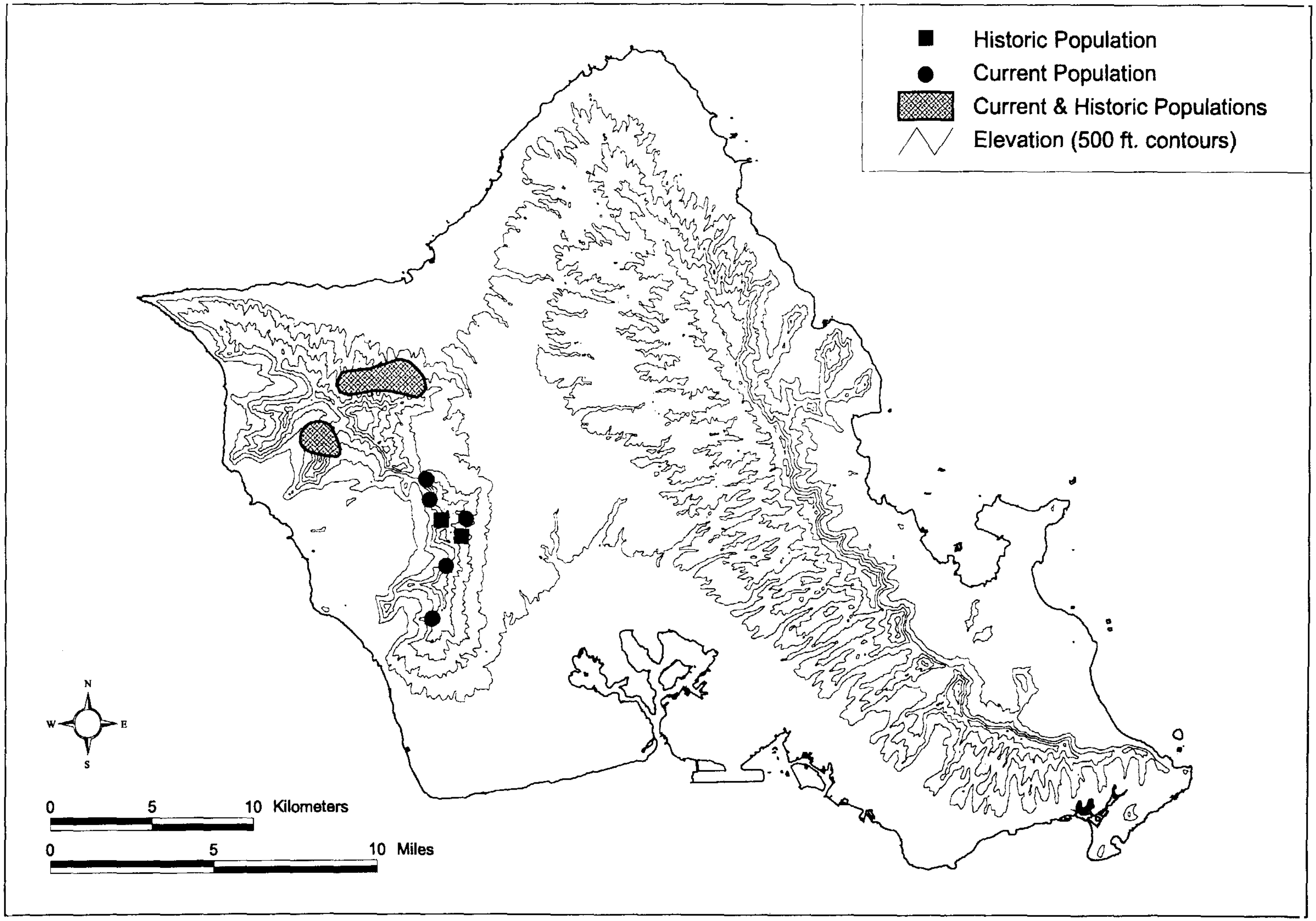
Viola oahuensis

Line drawing of *Viola oahuensis* from Wagner et al. (1990).

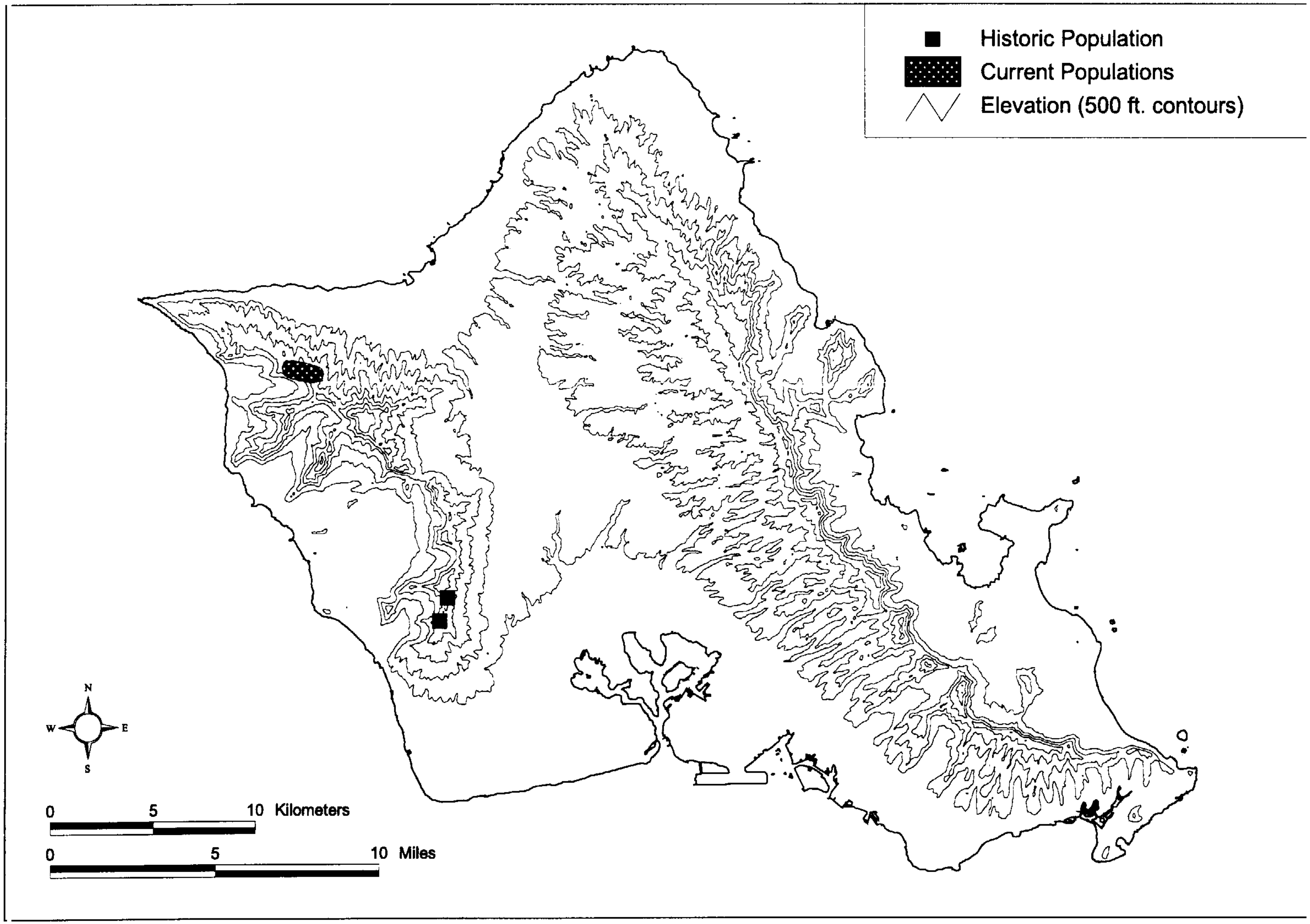
APPENDIX C

HISTORIC AND CURRENT DISTRIBUTION MAPS

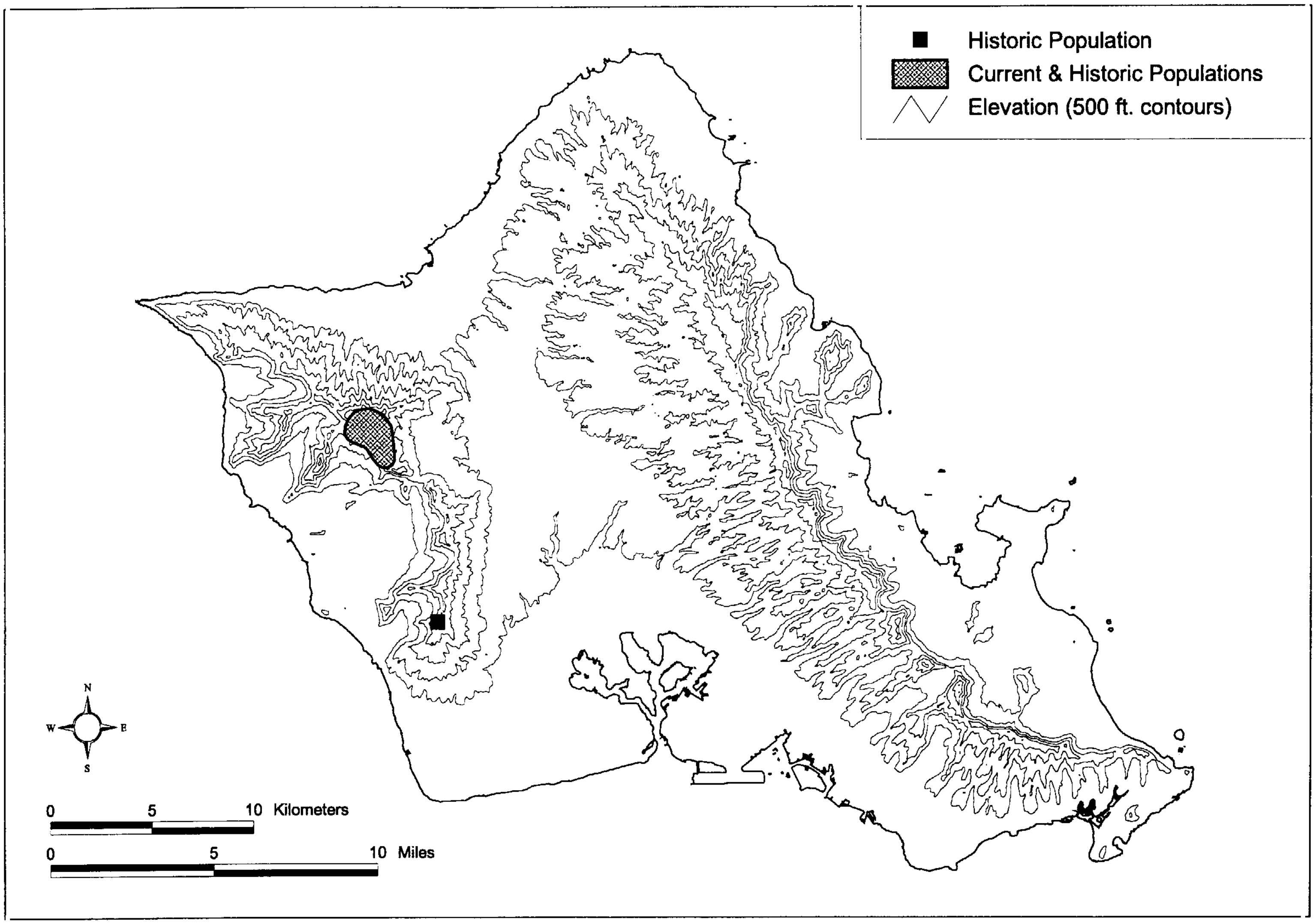
Historic distributions are estimates based on the best available information.



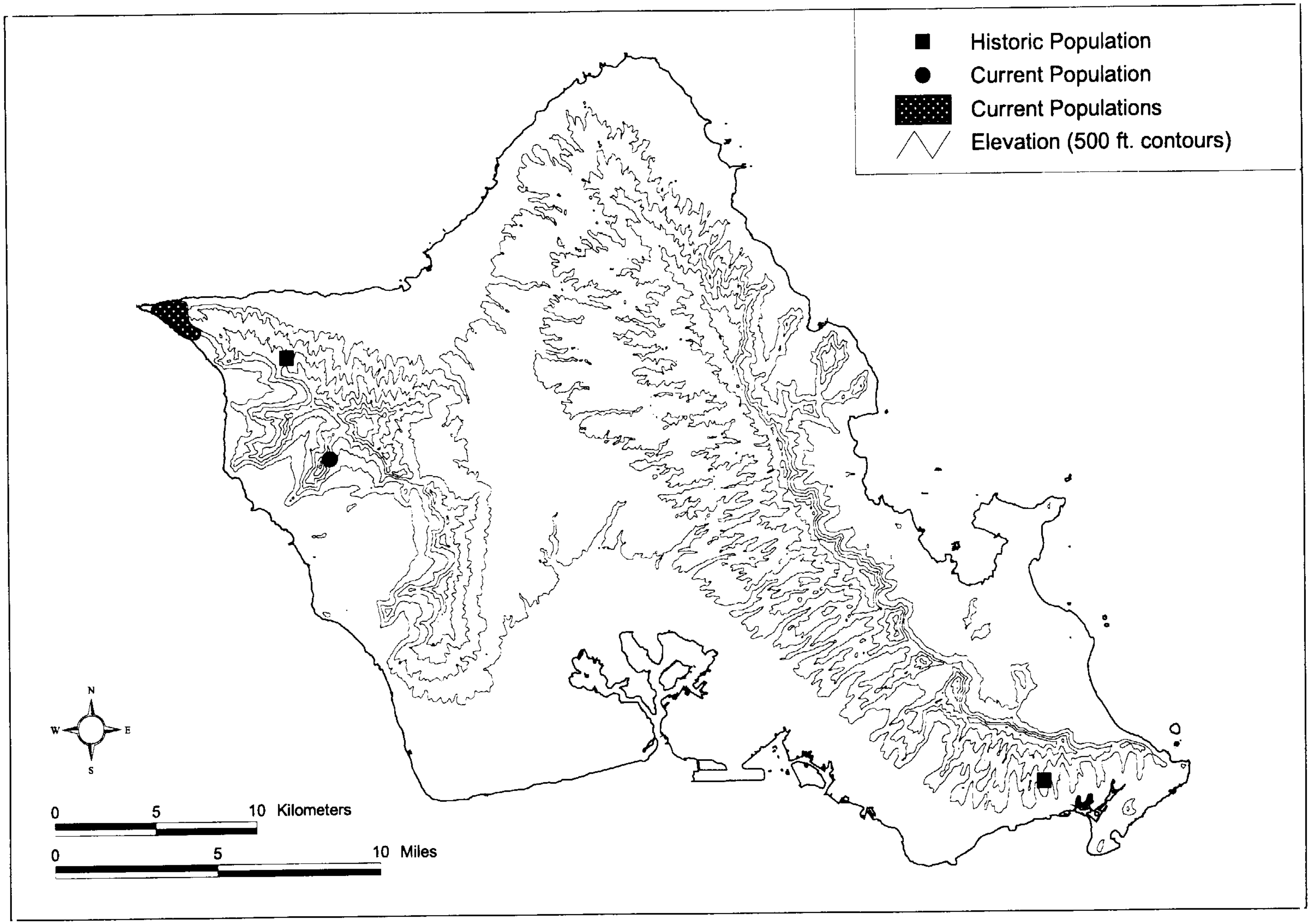
Distribution of *Abutilon sandwicense*



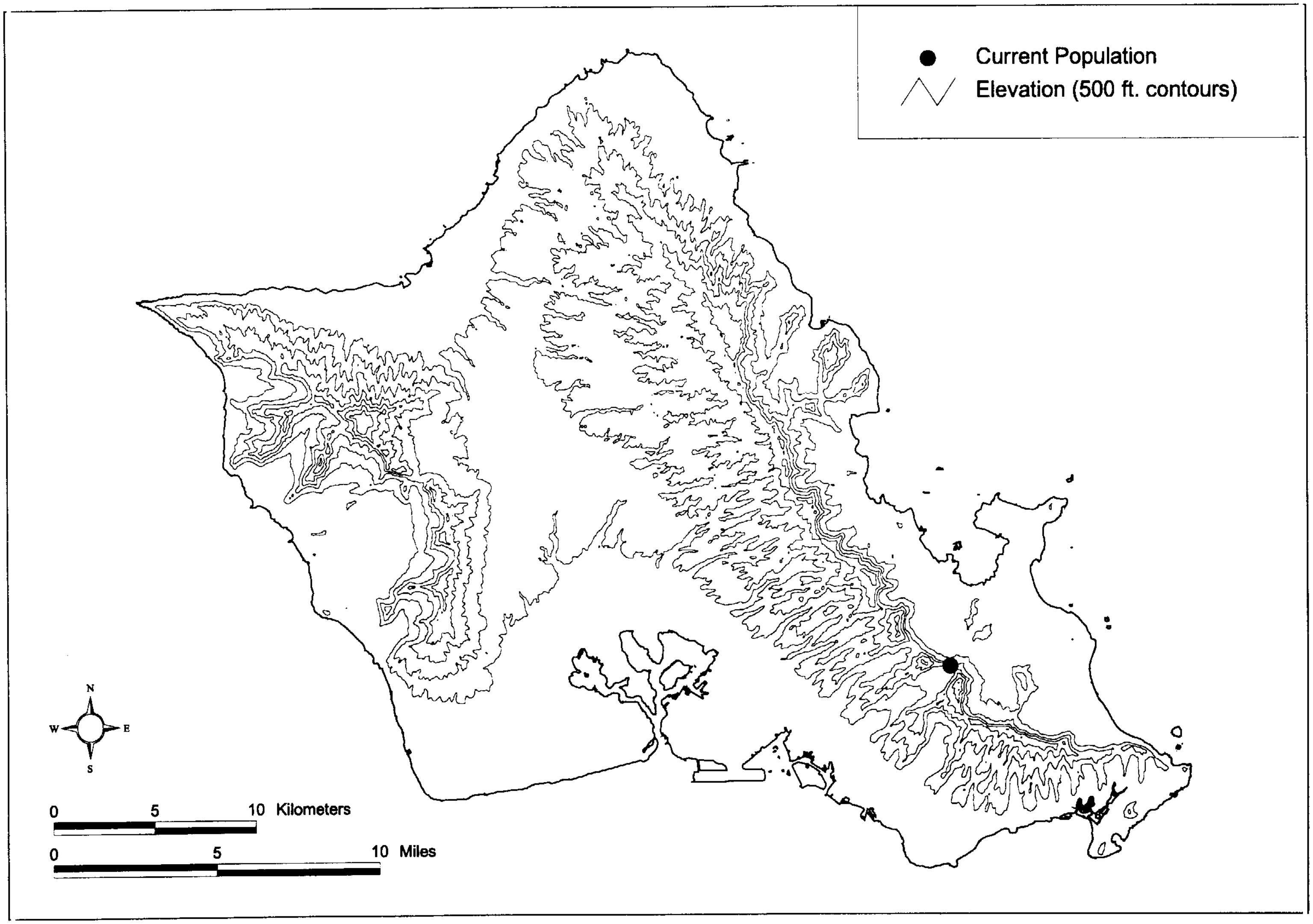
Distribution of *Alsinidendron obovatum*



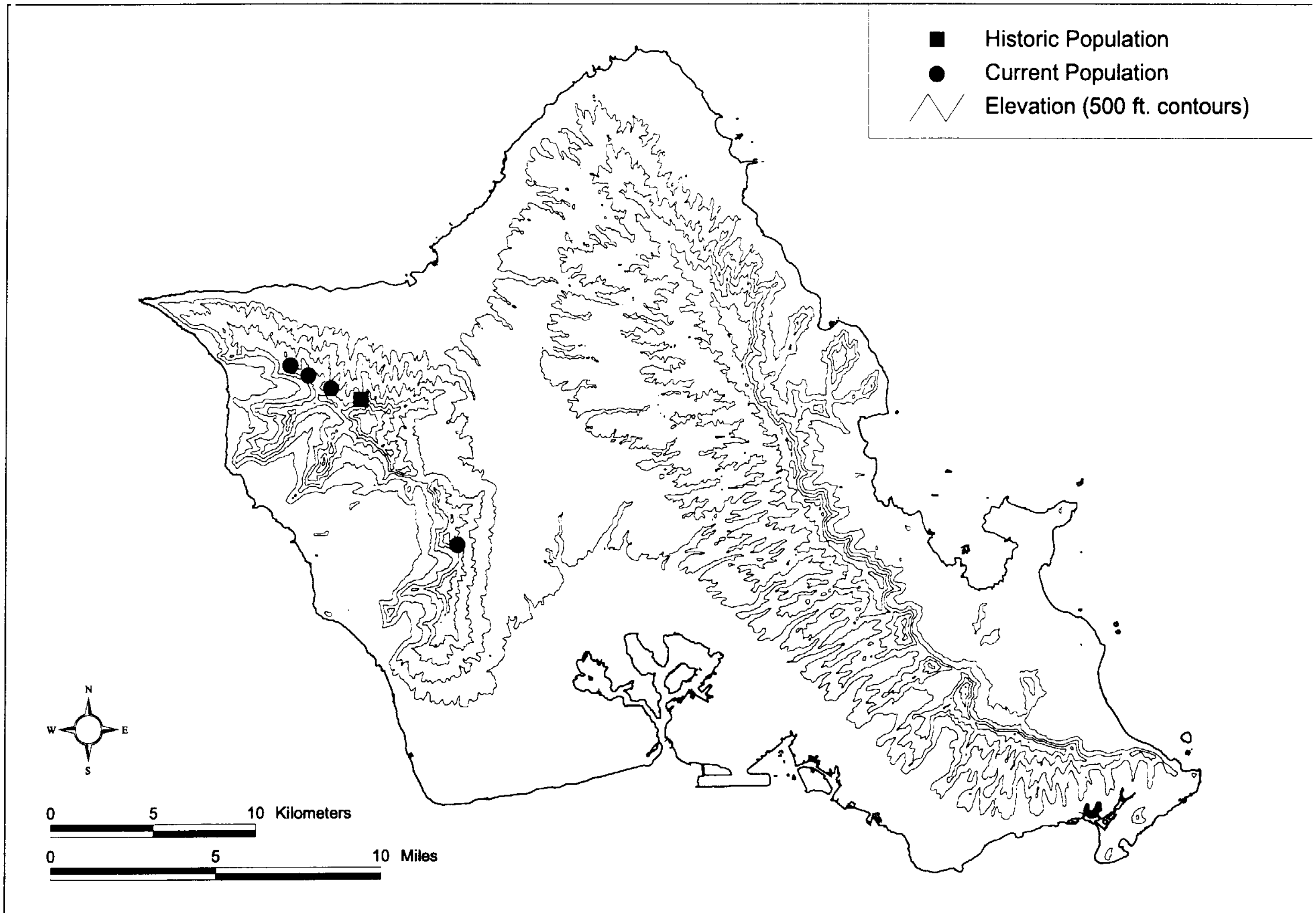
Distribution of *Alsinidendron trinerve*



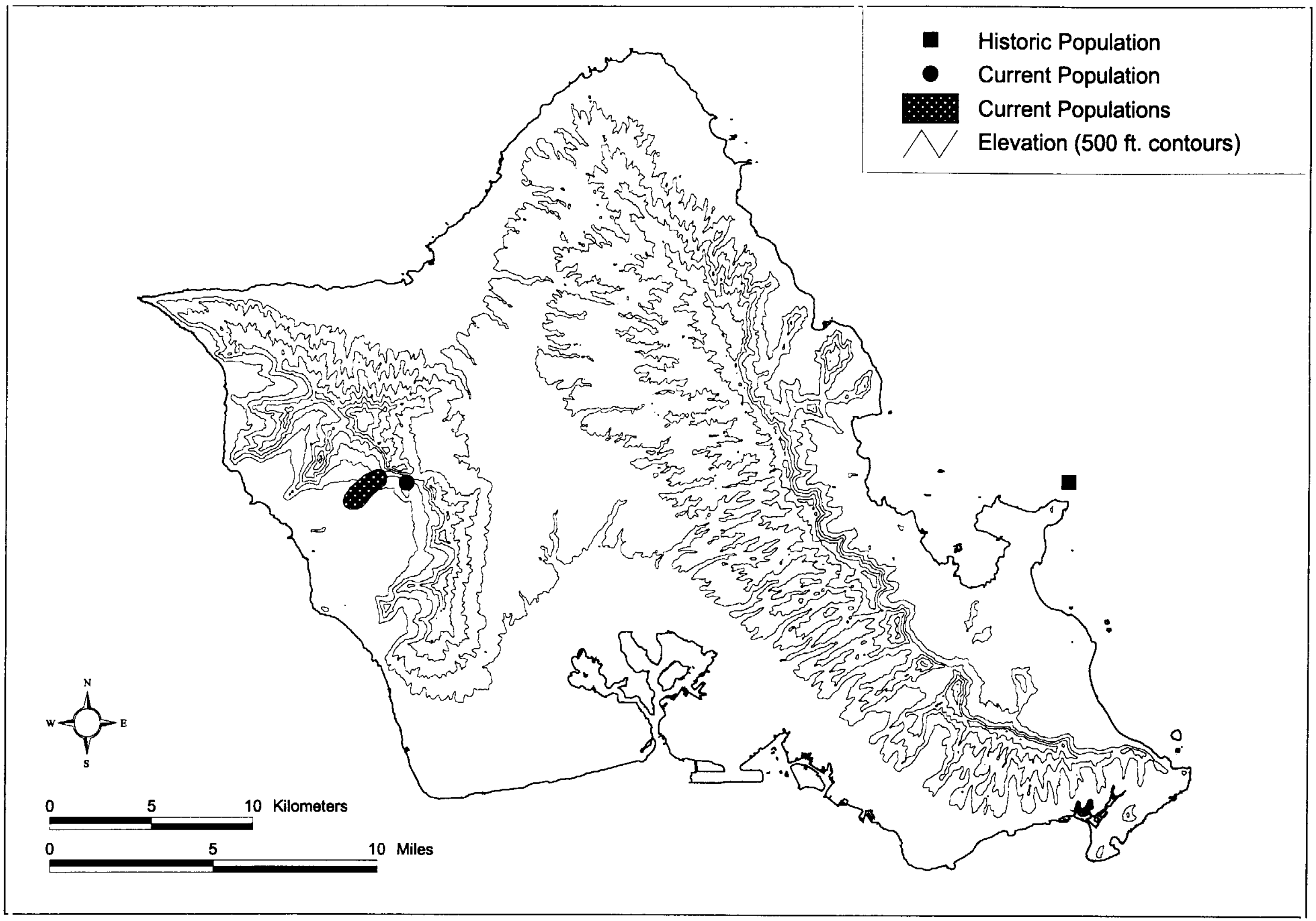
Distribution of *Chamaesyce celastroides* var. *kaenana*



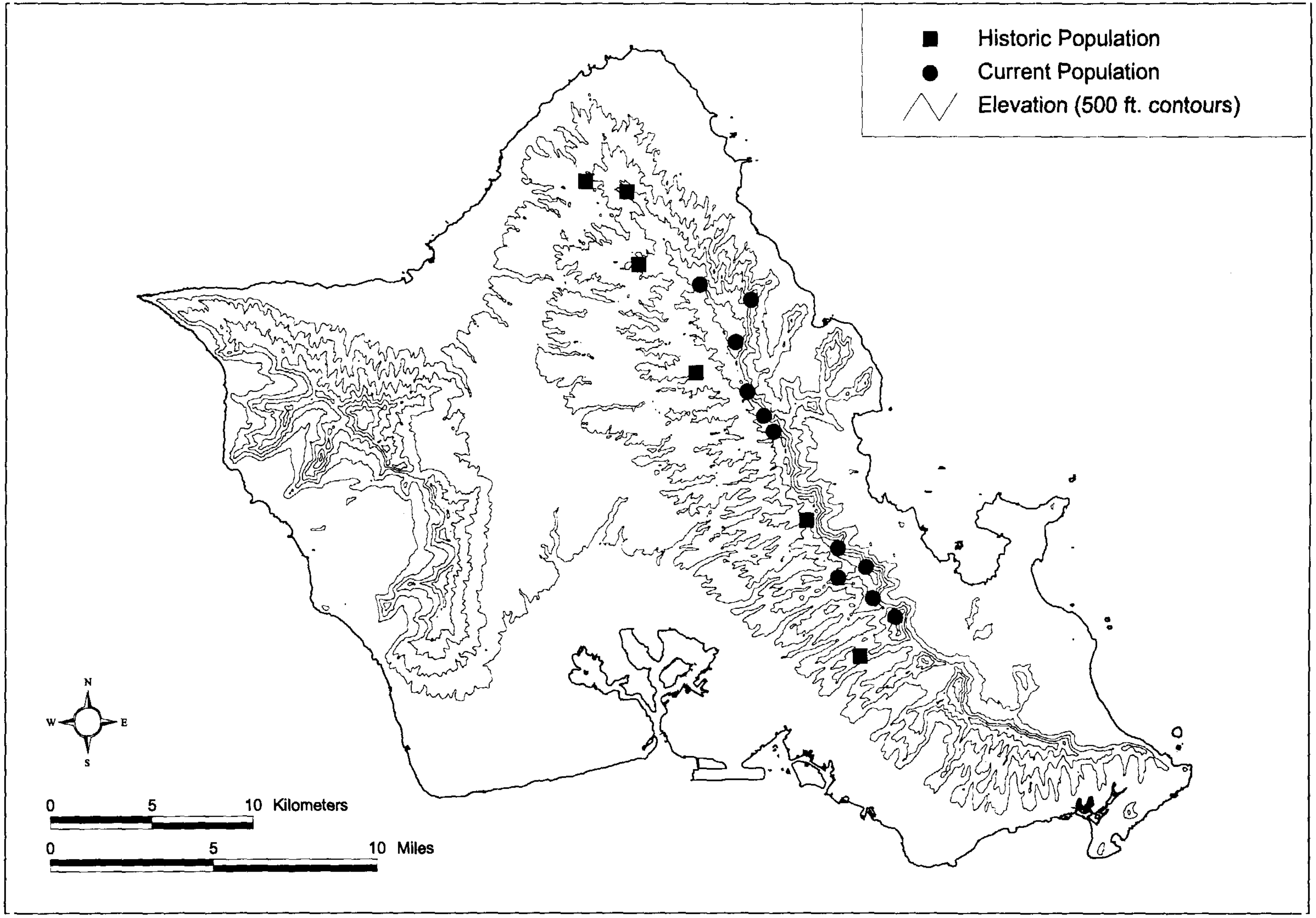
Distribution of *Chamaesyce deppeana*



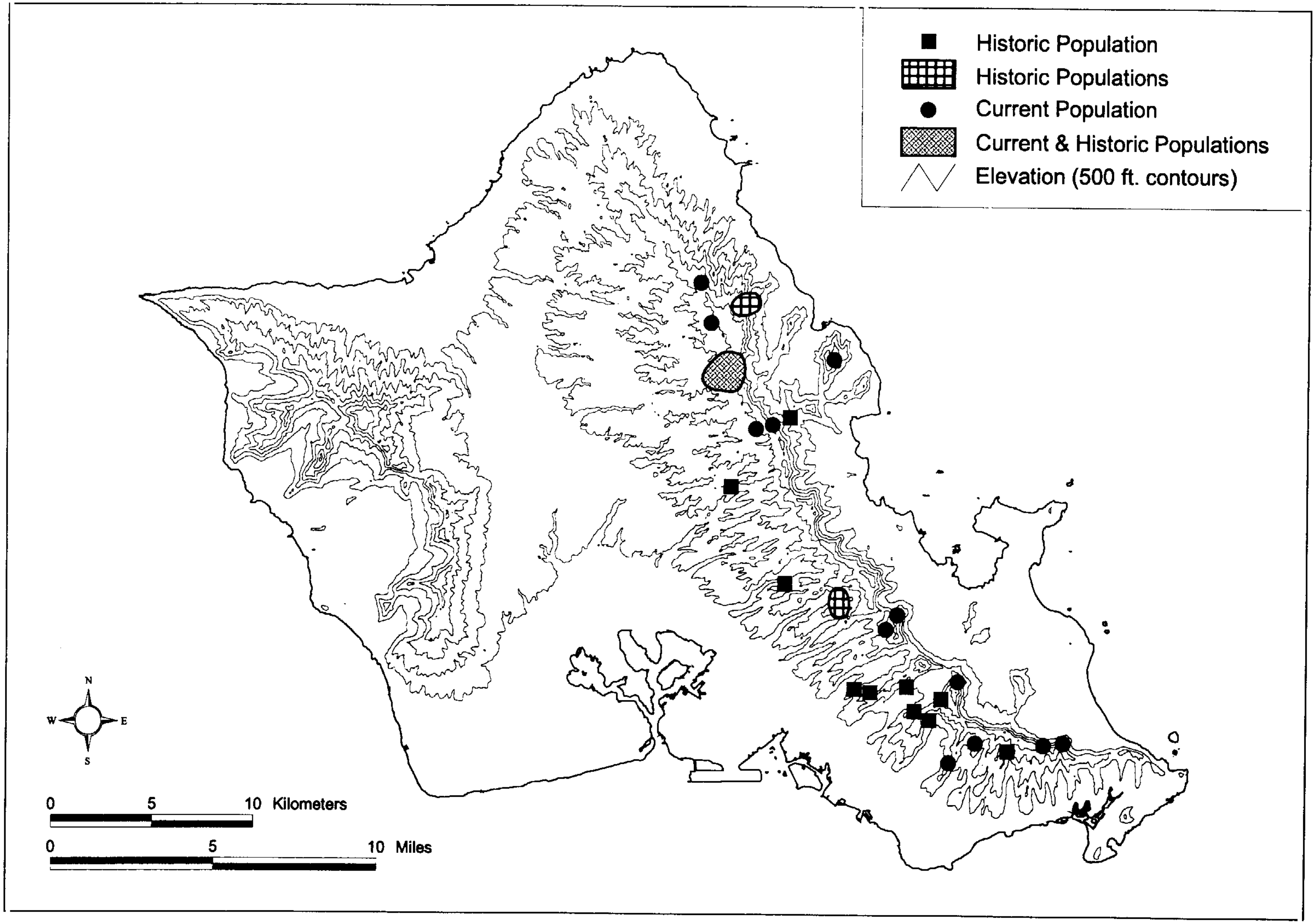
Distribution of *Chamaesyce herbstii*



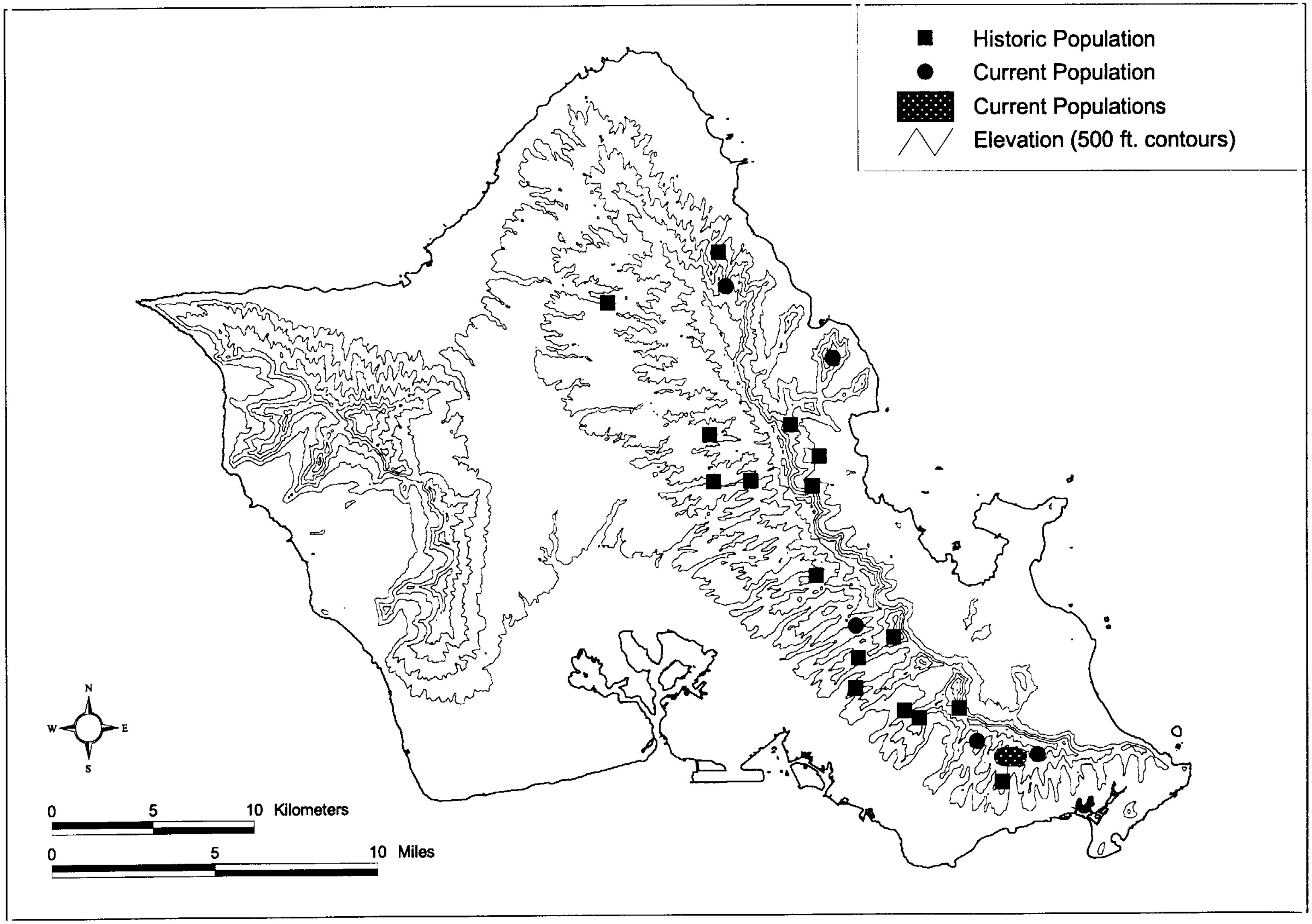
Distribution of *Chamaesyce kuwaleana*



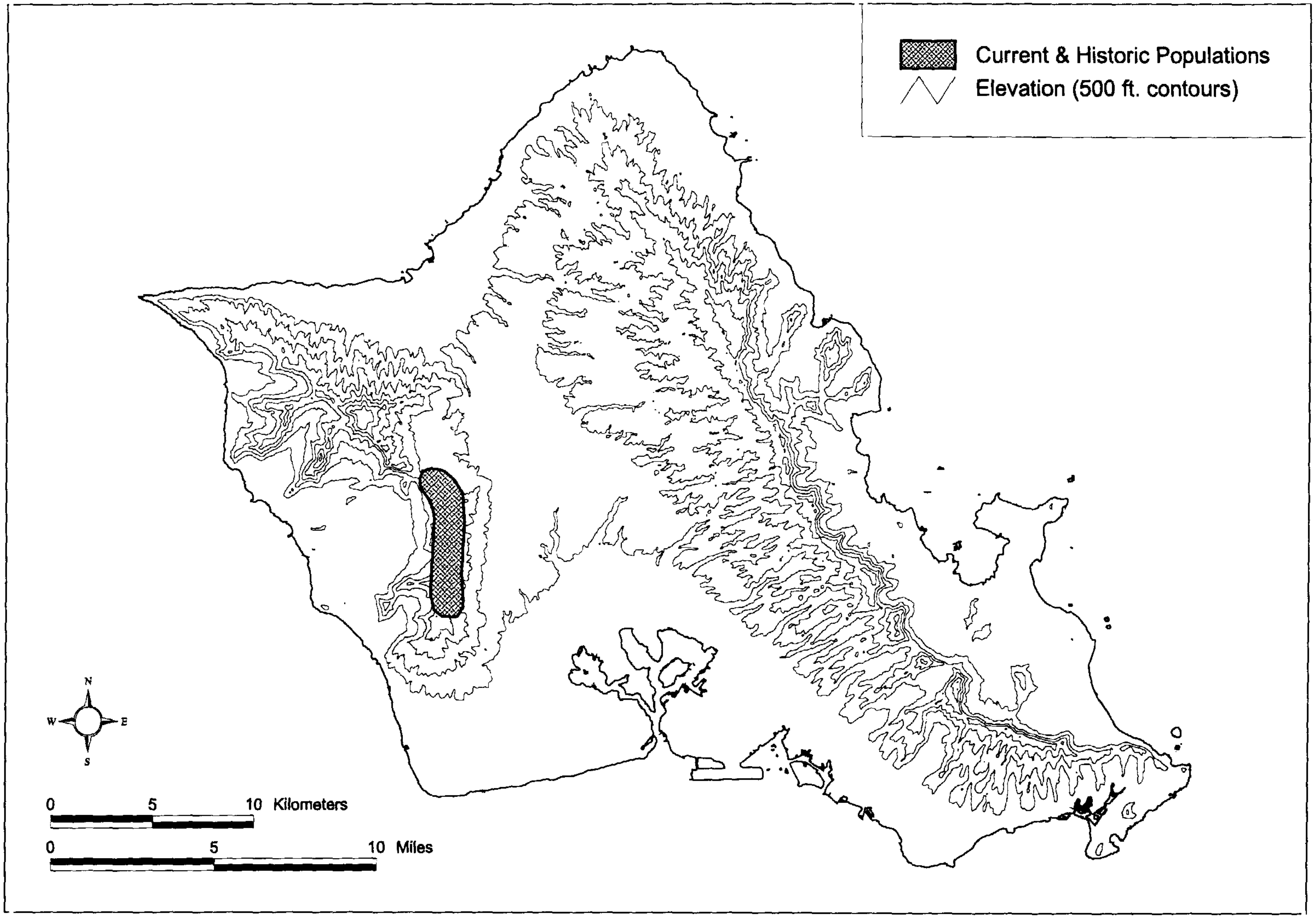
Distribution of *Chamaesyce rockii*



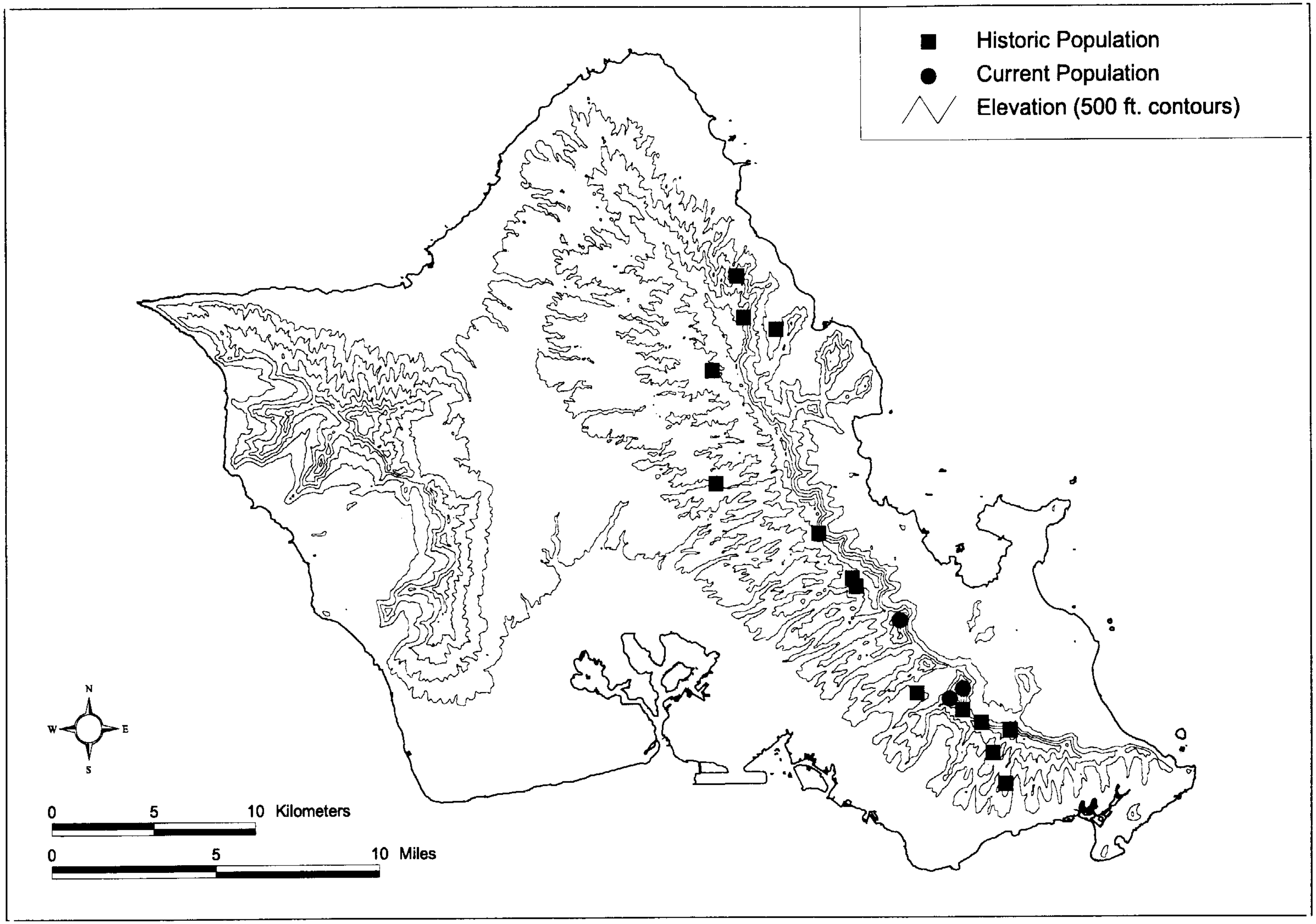
Distribution of *Cyanea acuminata*



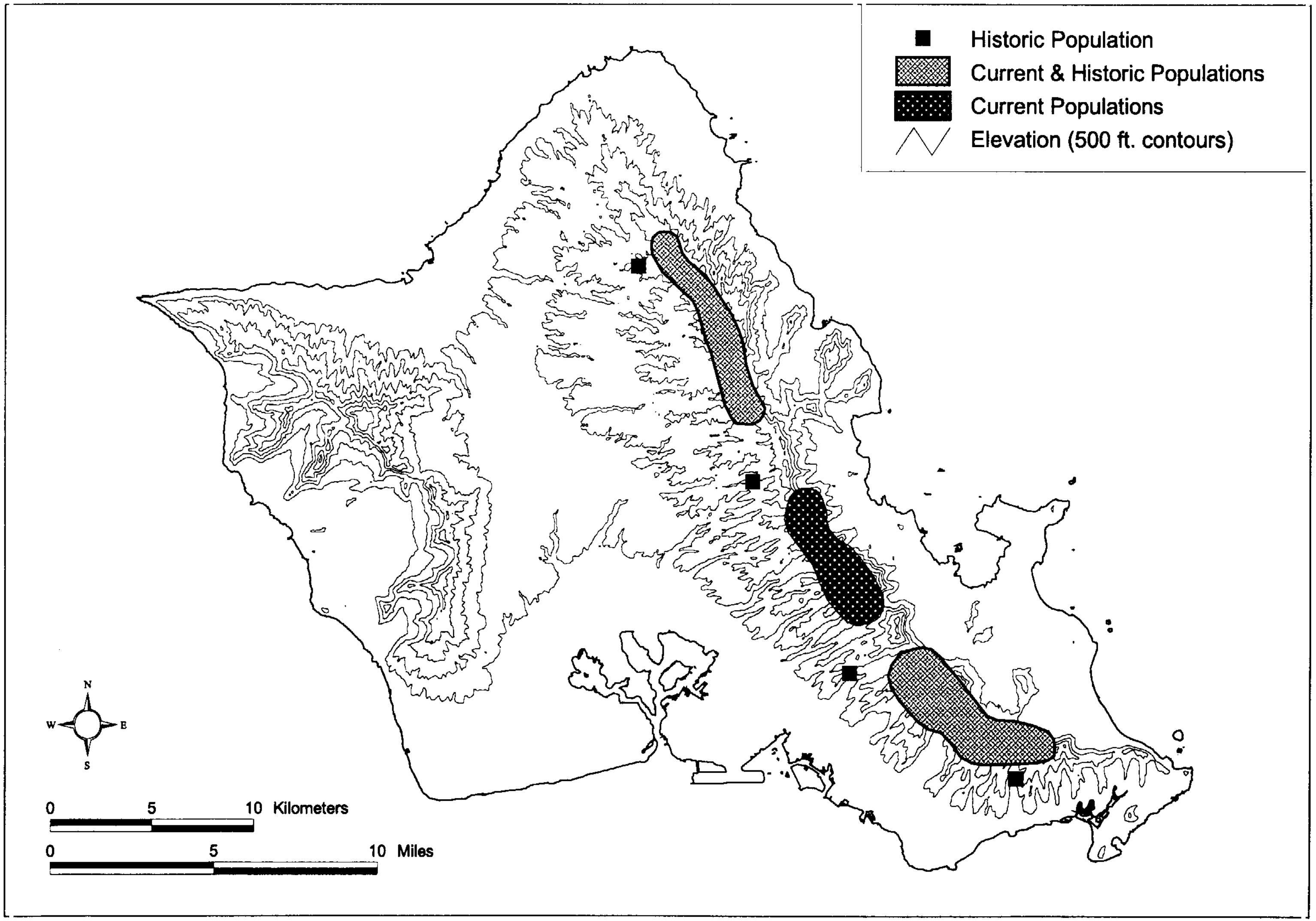
Distribution of *Cyanea crispa*



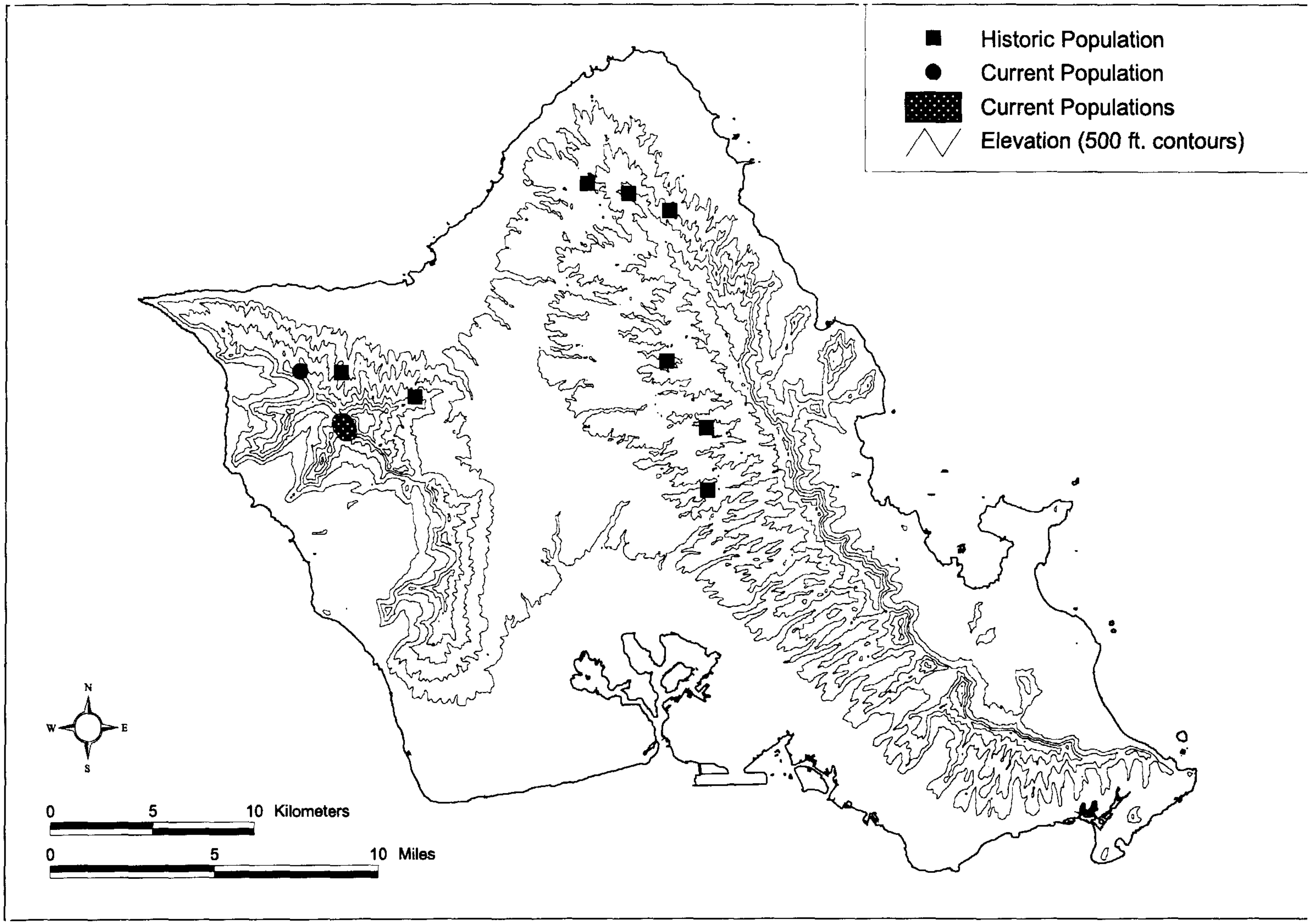
Distribution of *Cyanea grimesiana* ssp. *obatae*



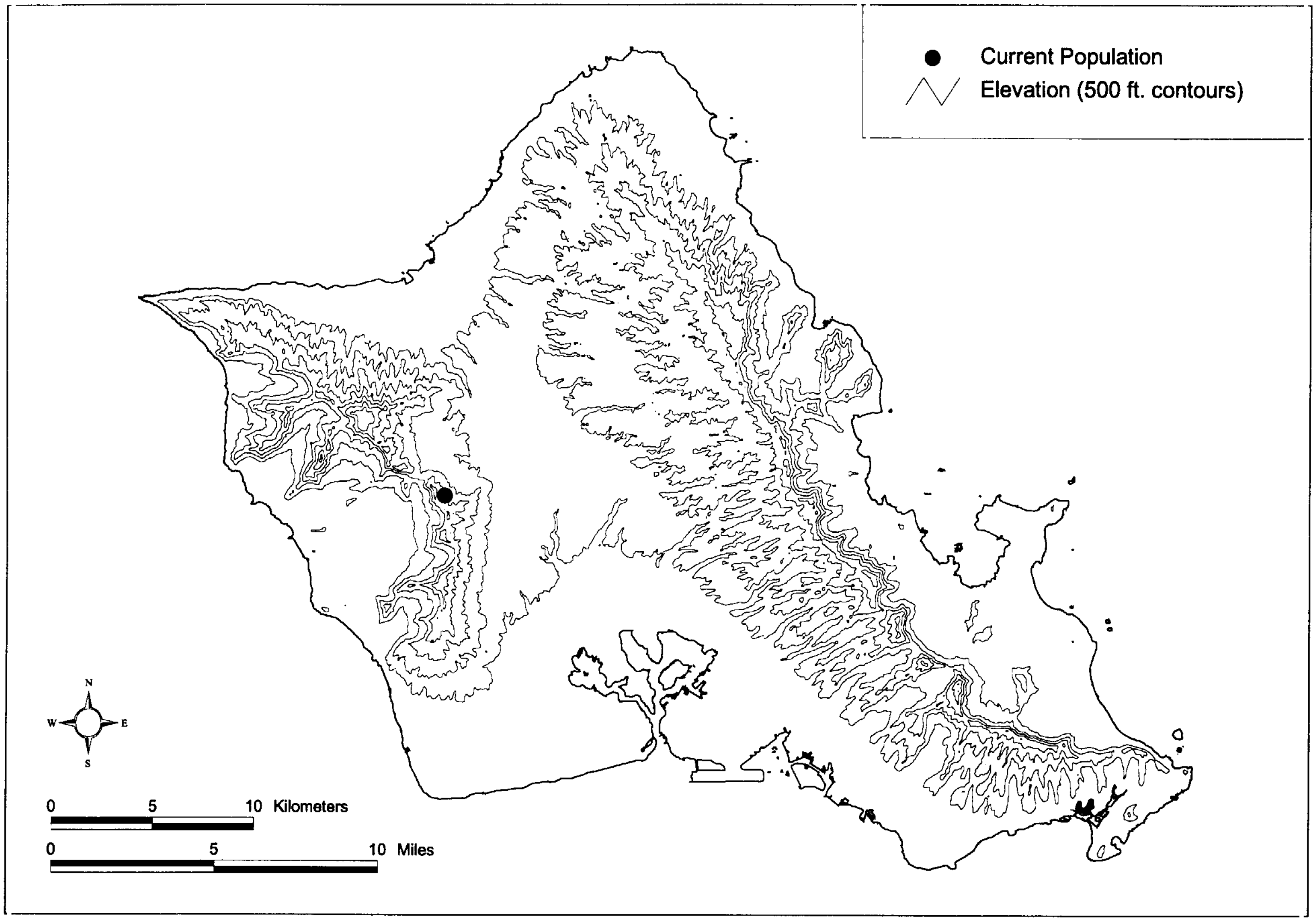
Distribution of *Cyanea humboldtiana*



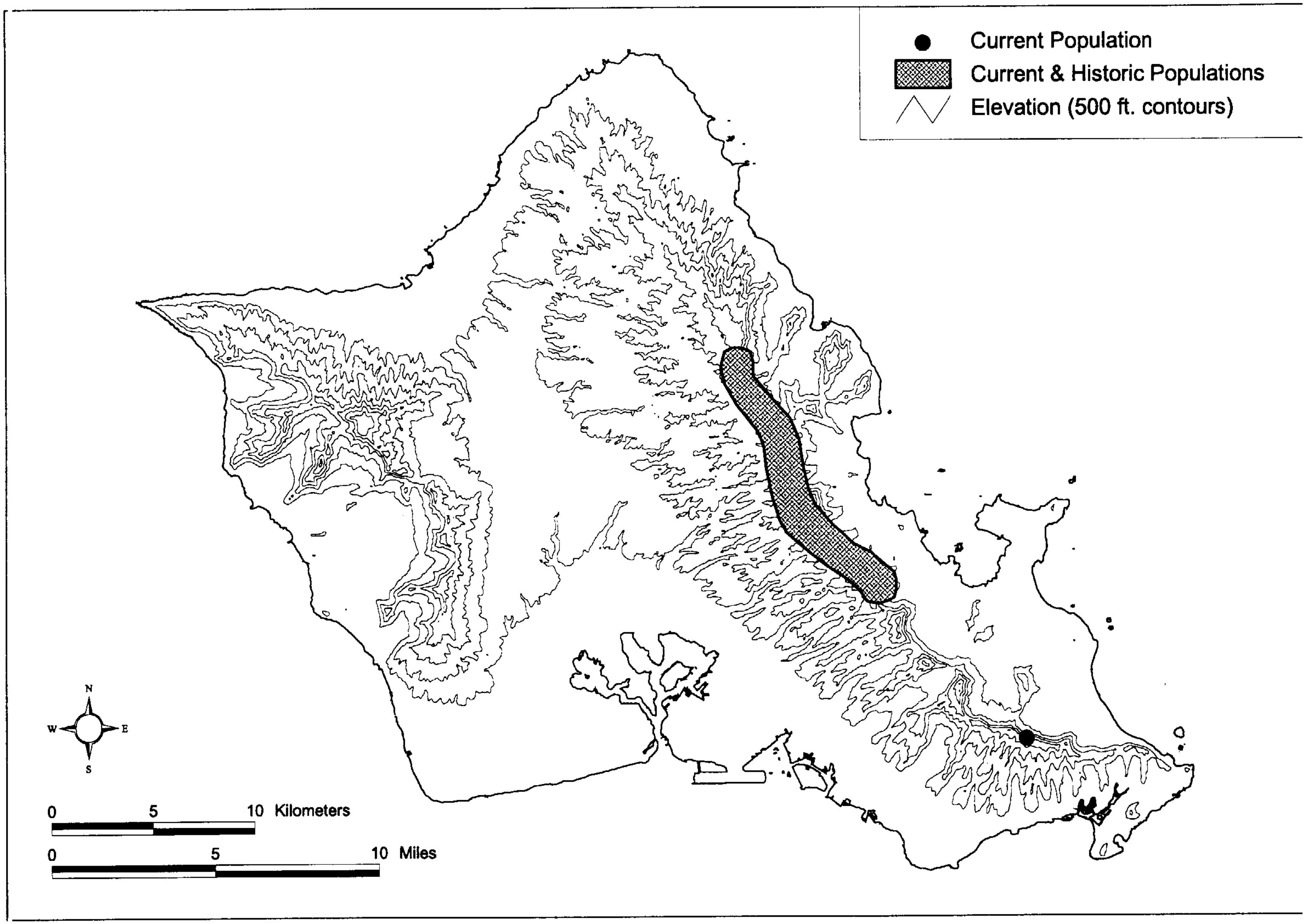
Distribution of *Cyanea koolauensis*



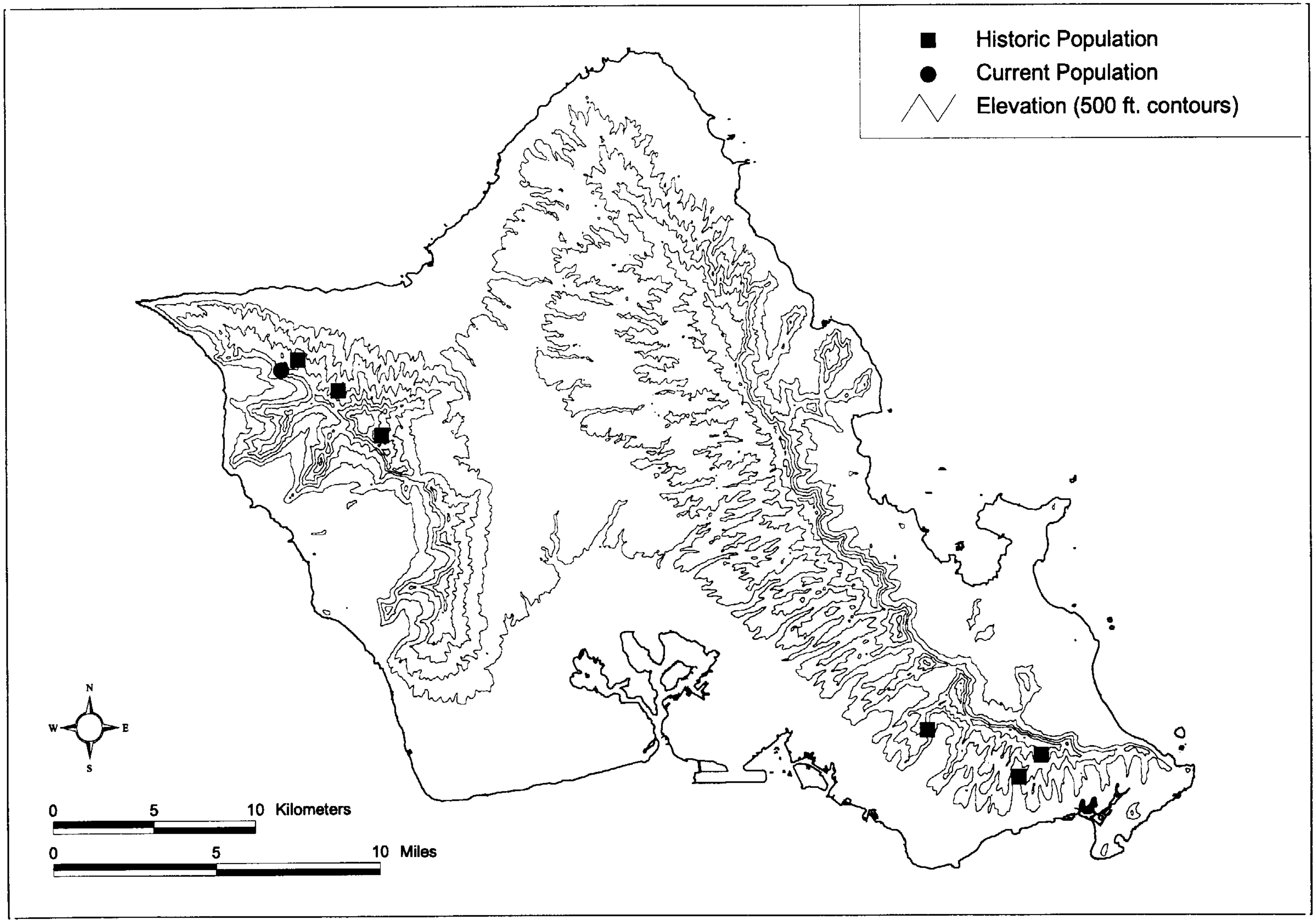
Distribution of *Cyanea longiflora*



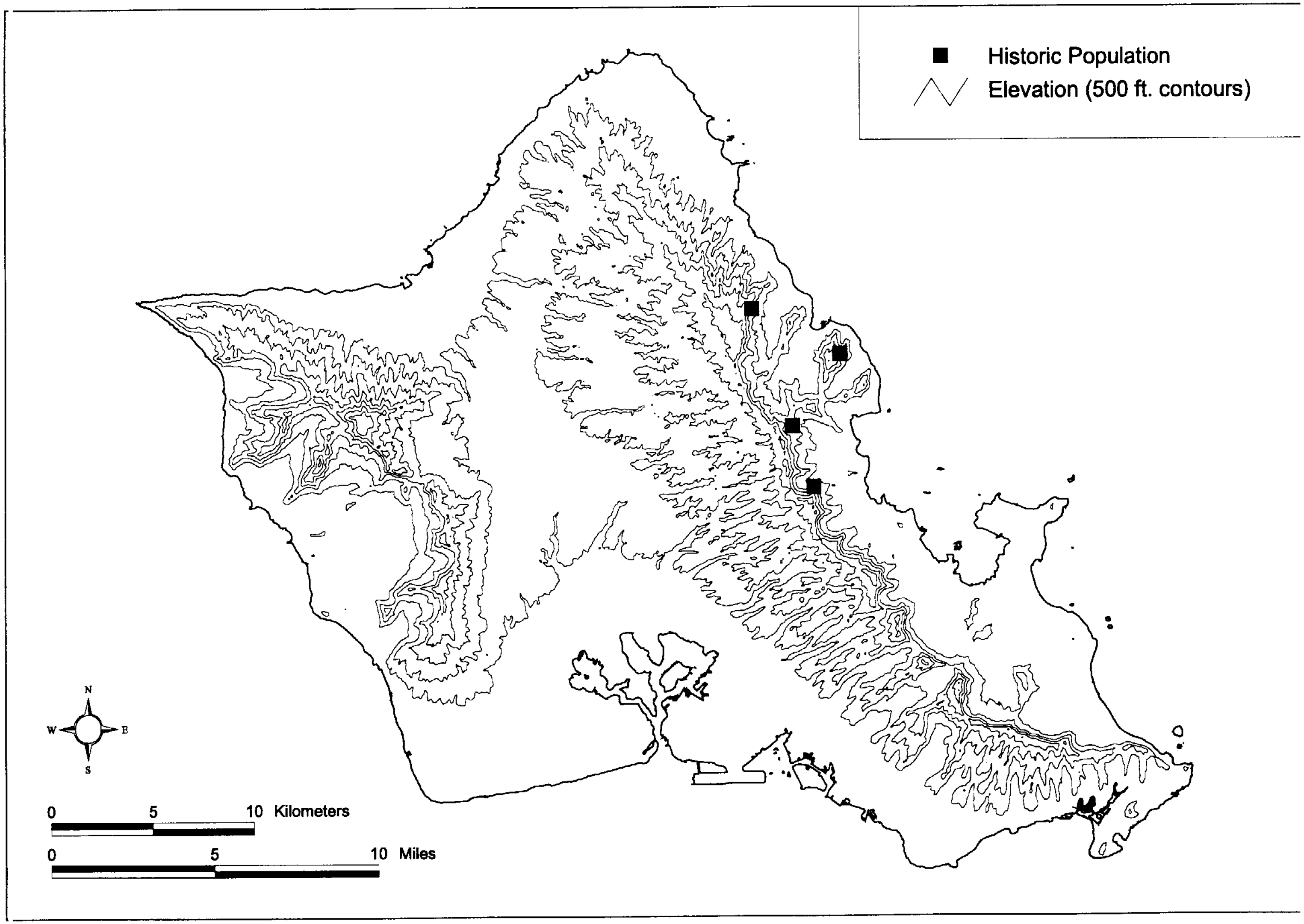
Distribution of *Cyanea pinnatifida*



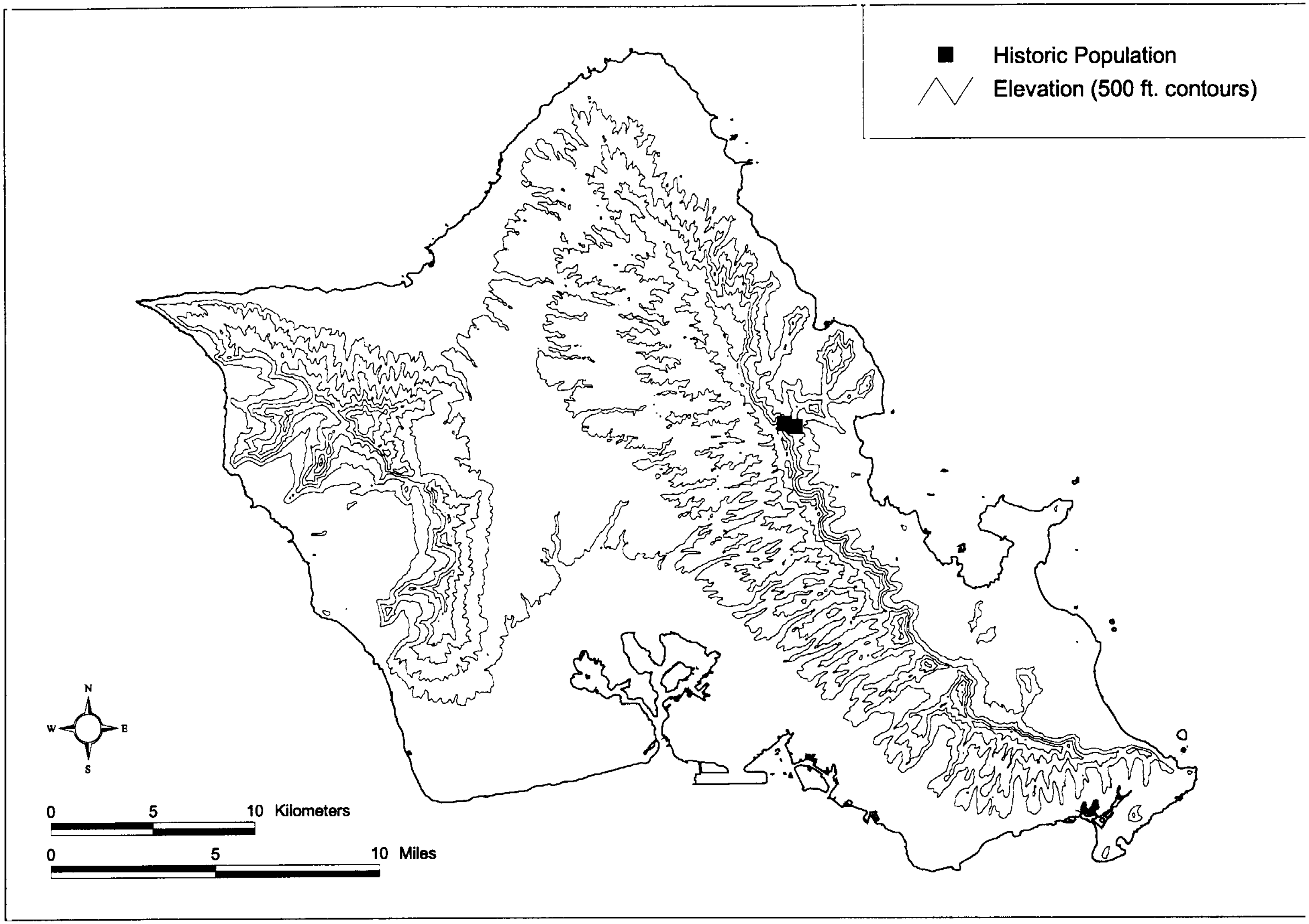
Distribution of *Cyanea st.-johnii*



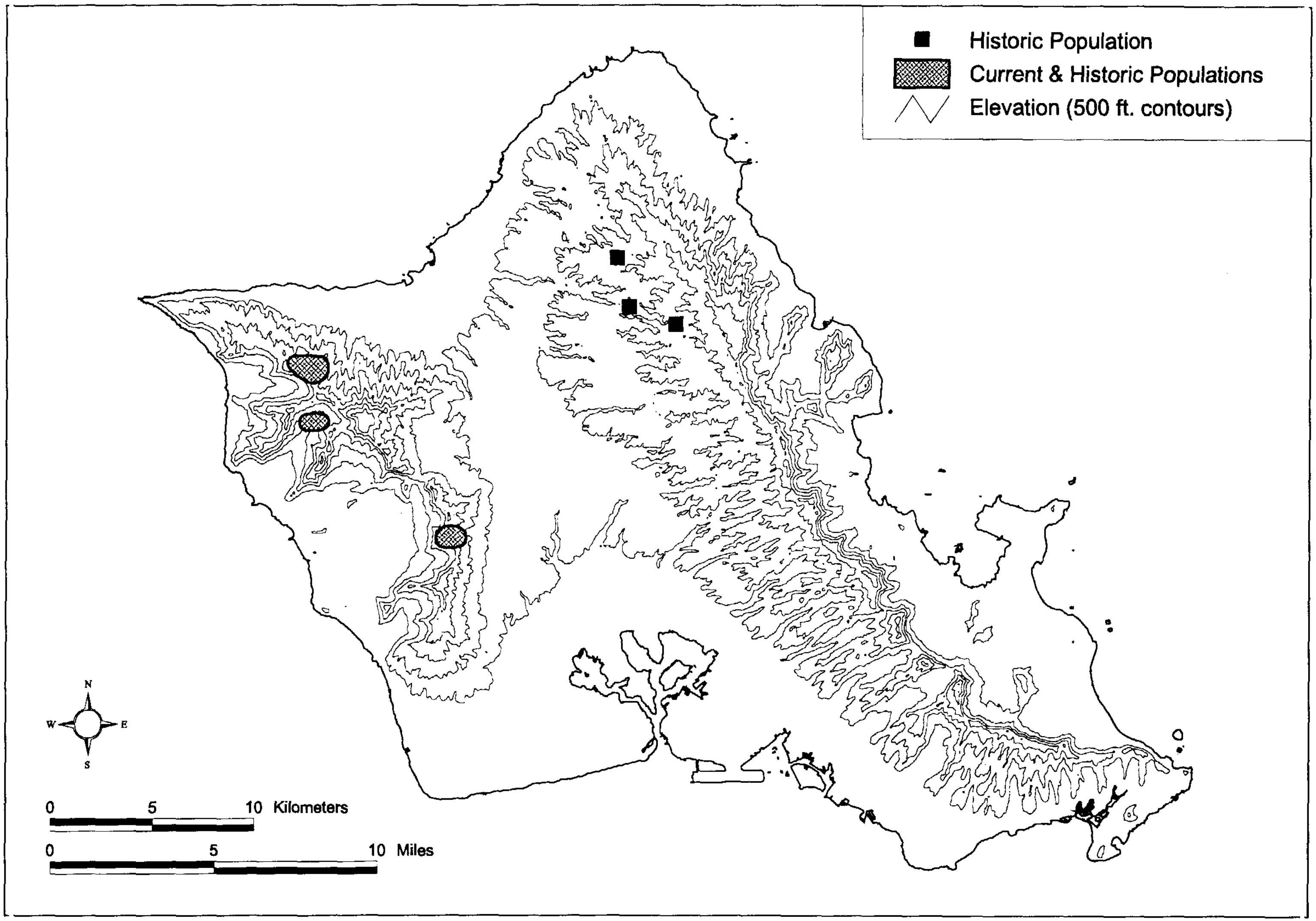
Distribution of *Cyanea superba*



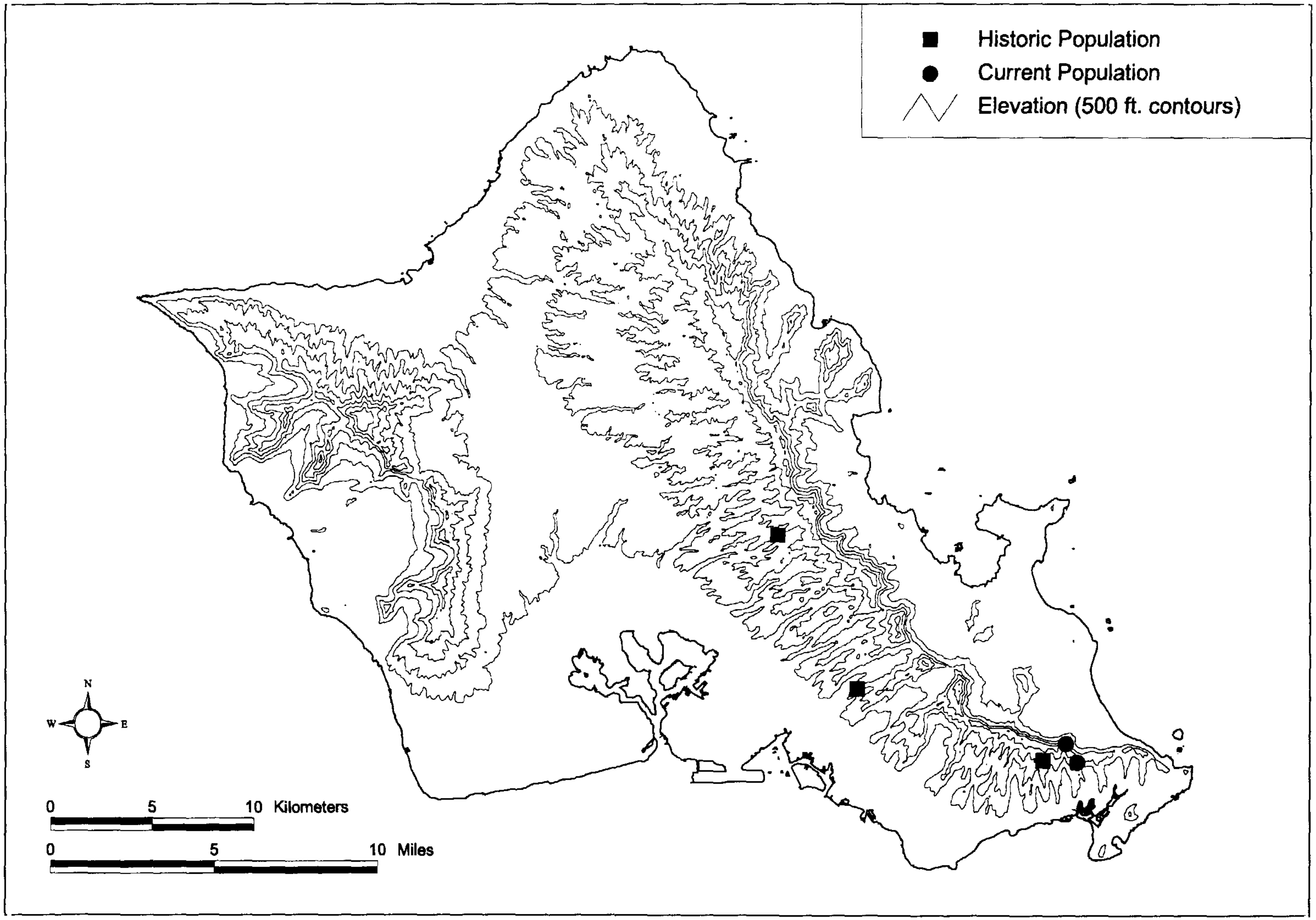
Distribution of *Cyanea truncata*



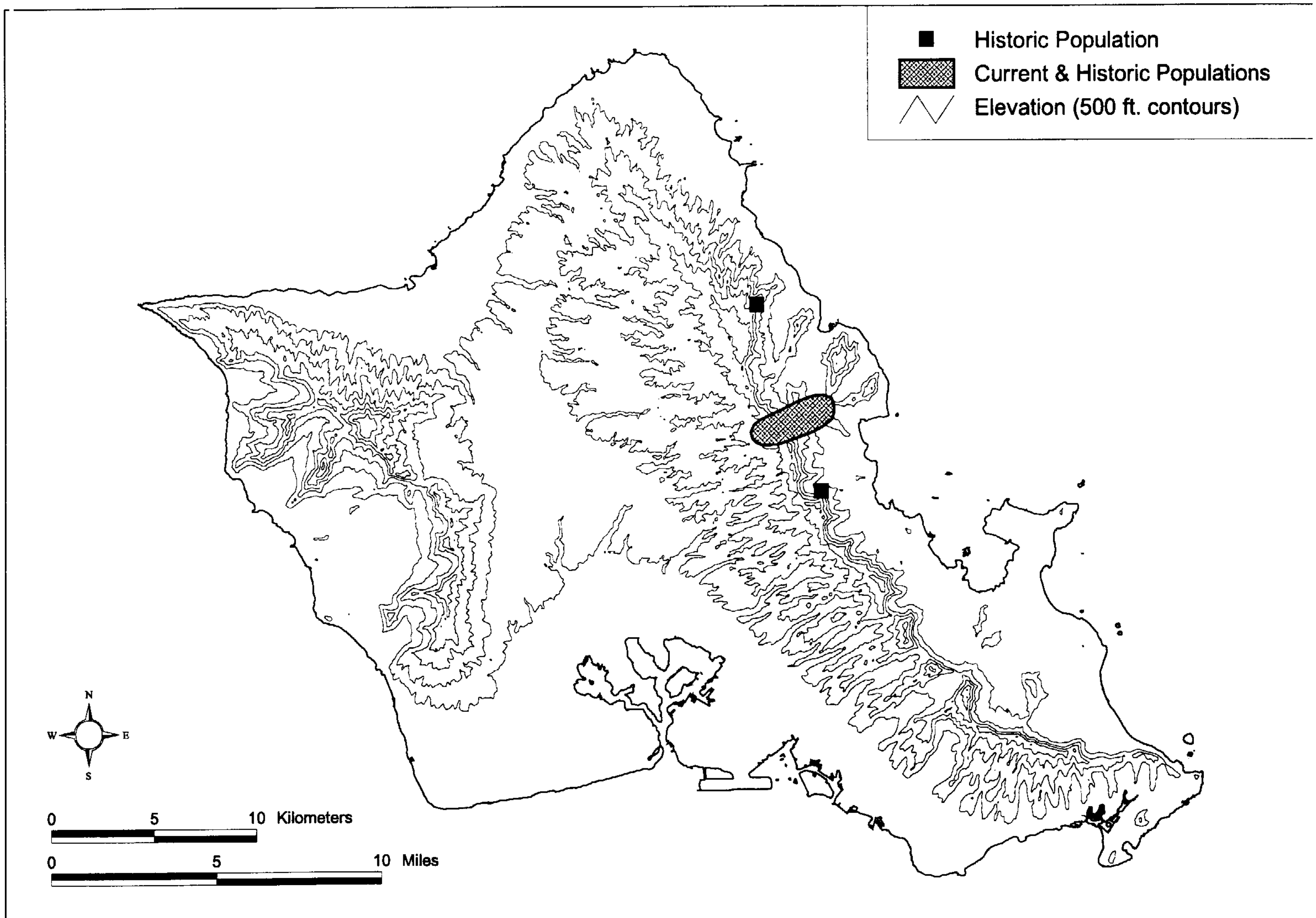
Distribution of *Cyrtandra crenata*



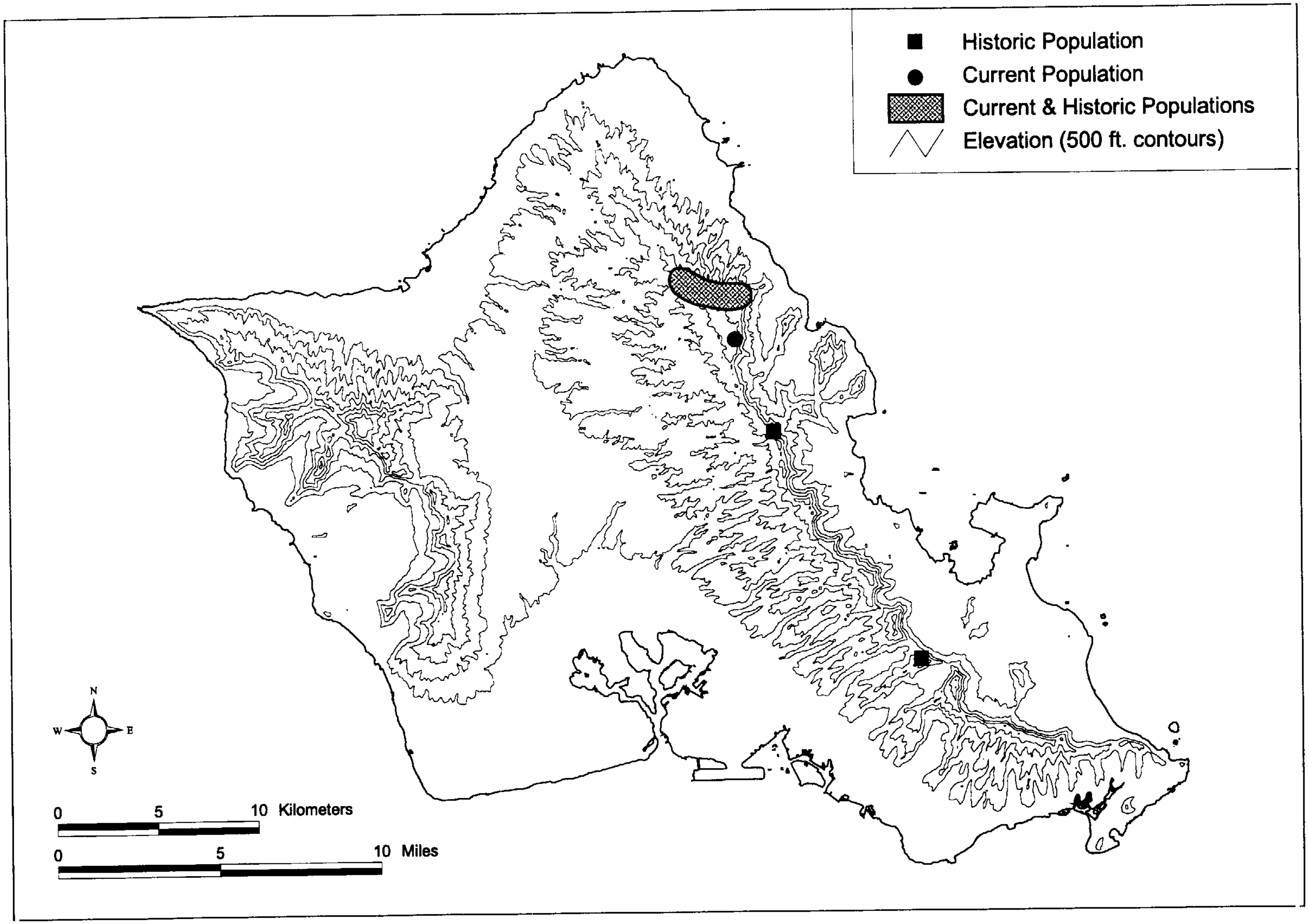
Distribution of *Cyrtandra dentata*



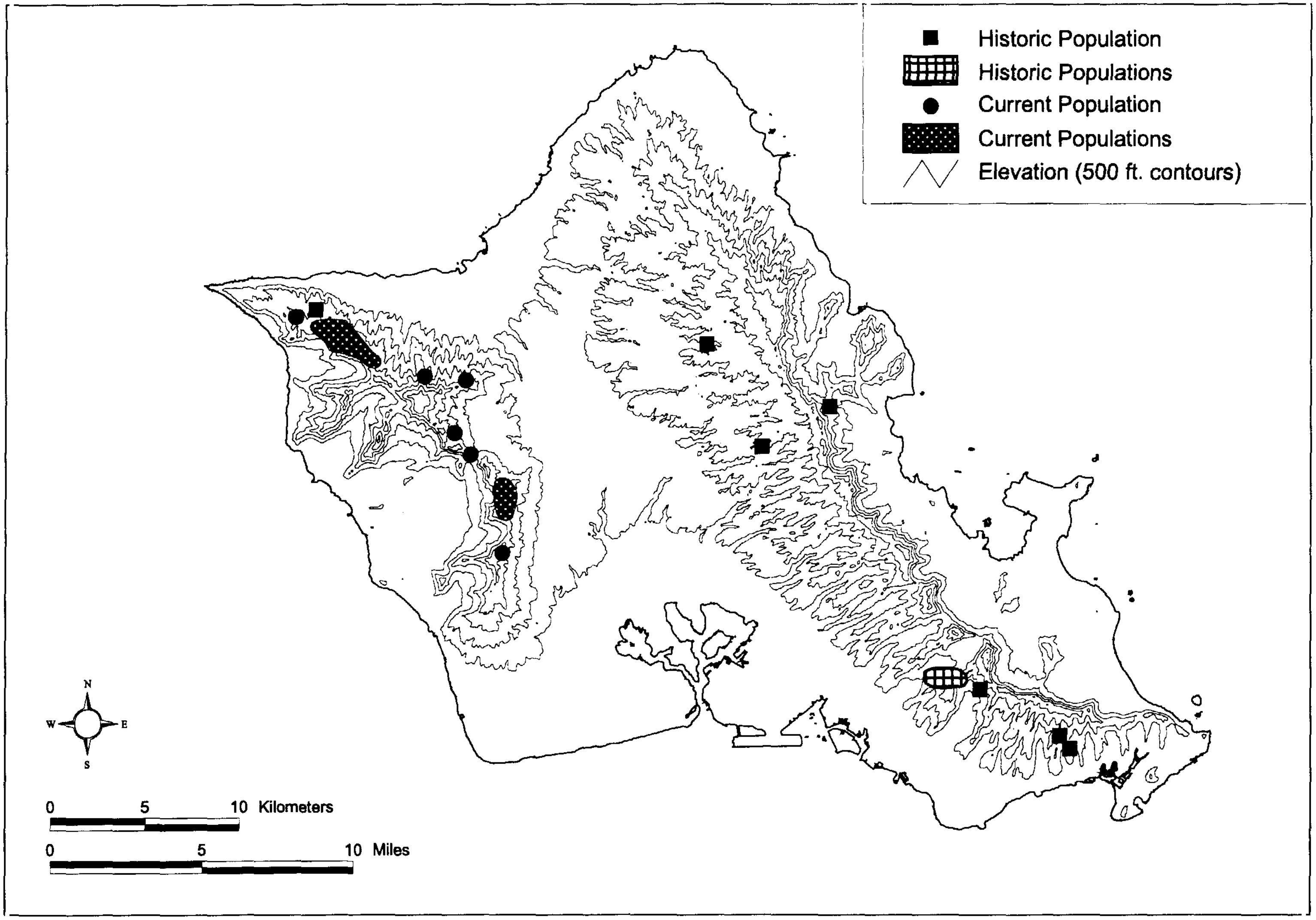
Distribution of *Cyrtandra polyantha*



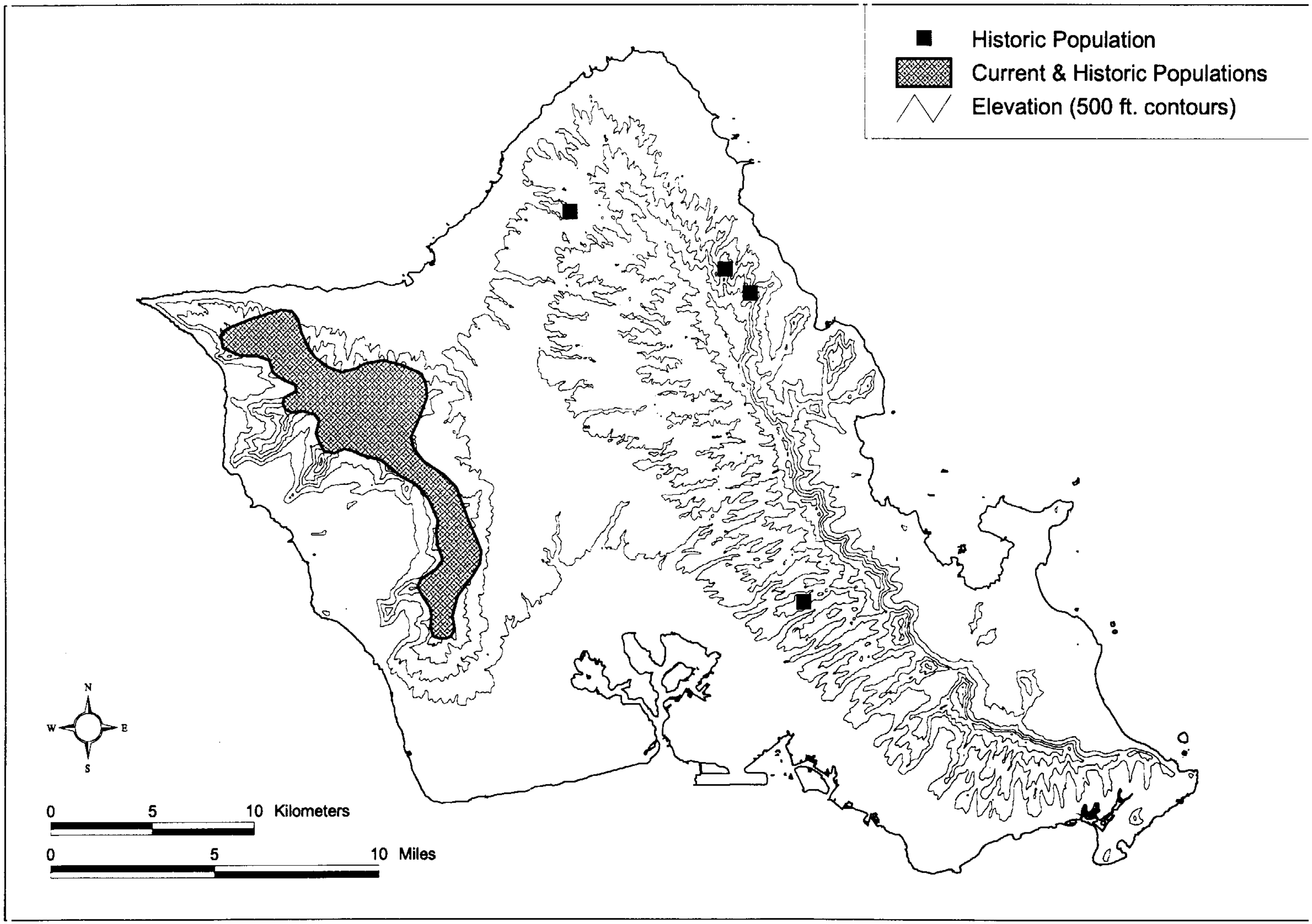
Distribution of *Cyrtandra subumbellata*



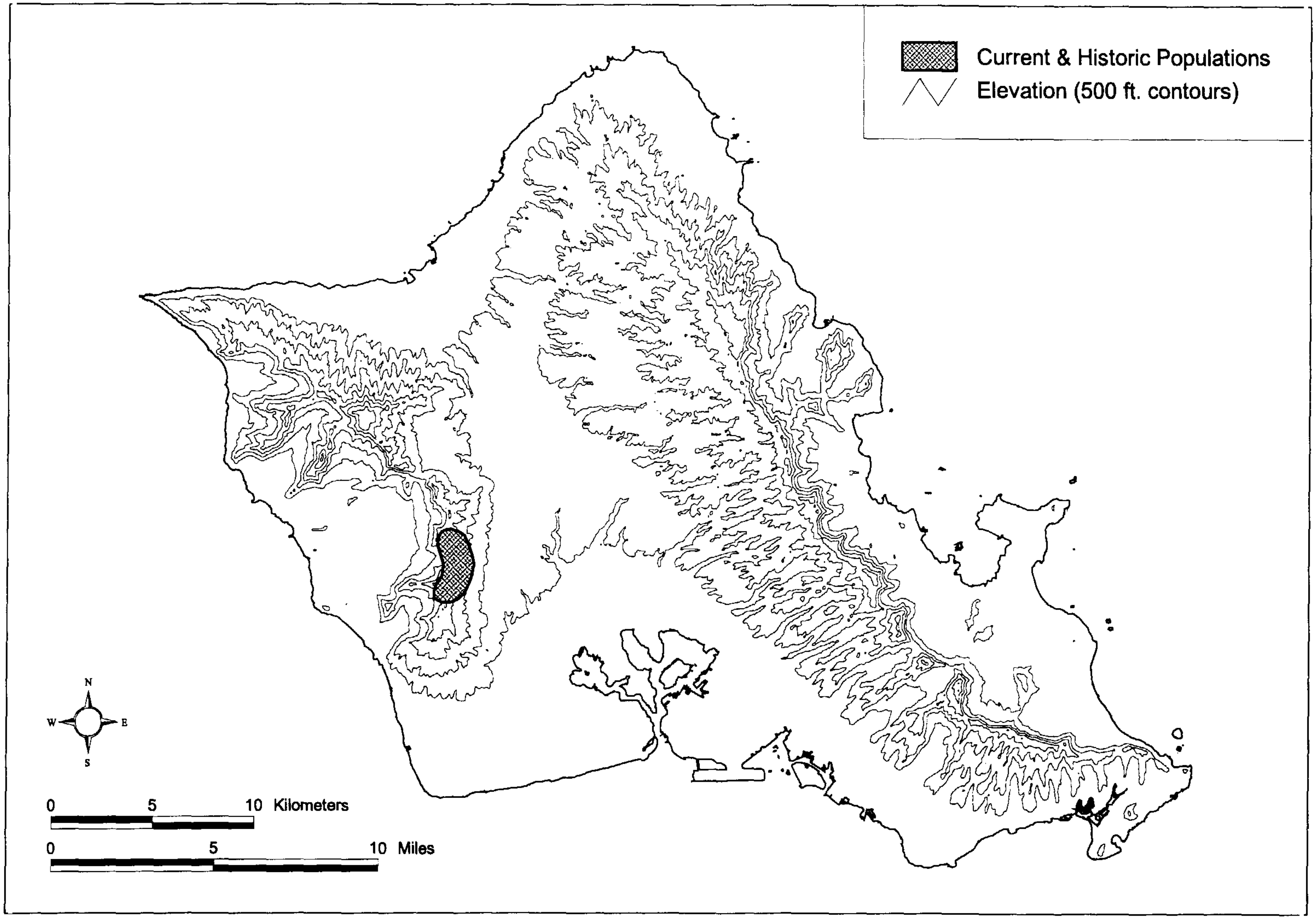
Distribution of *Cyrtandra viridiflora*



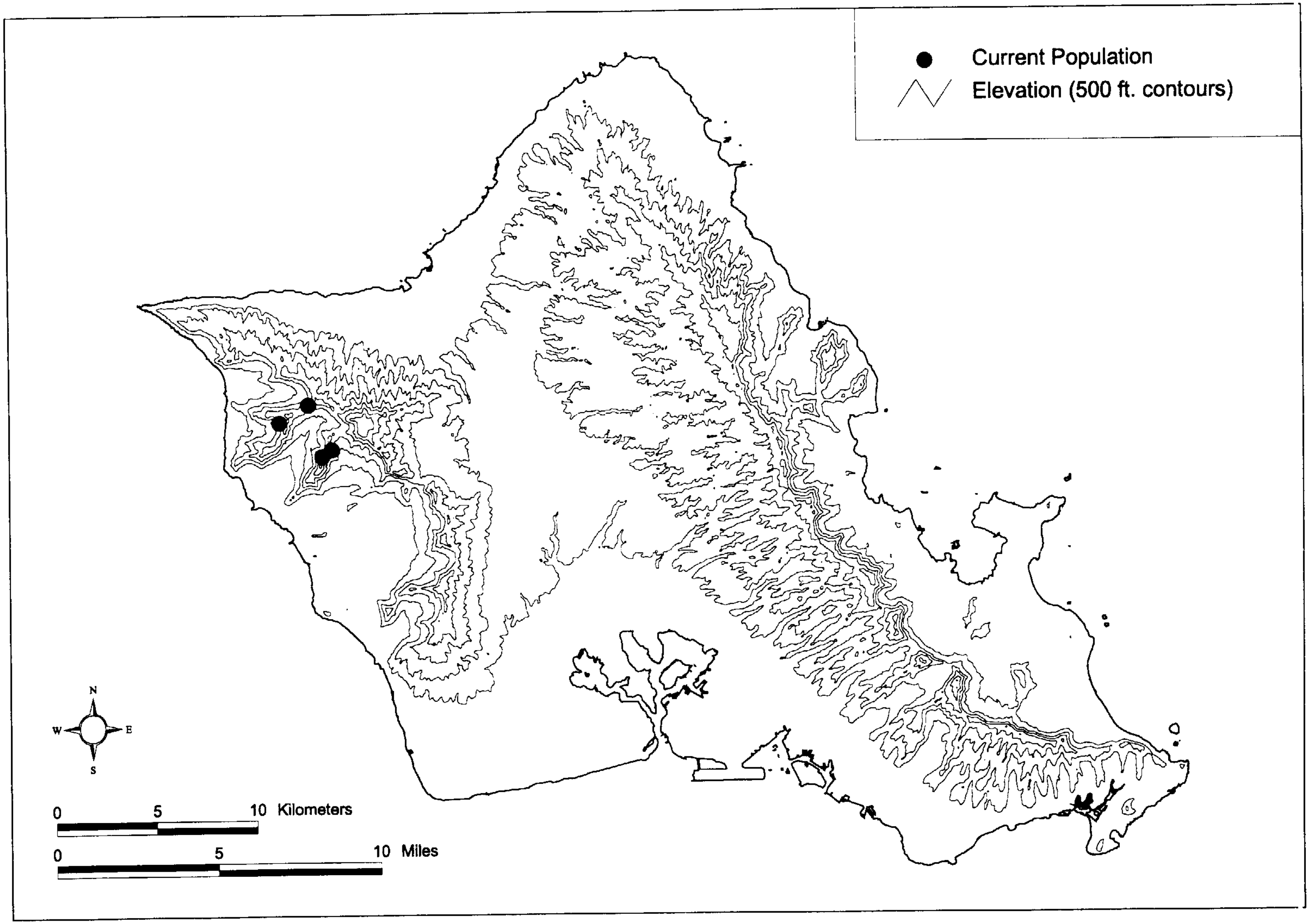
Distribution of *Delissea subcordata*



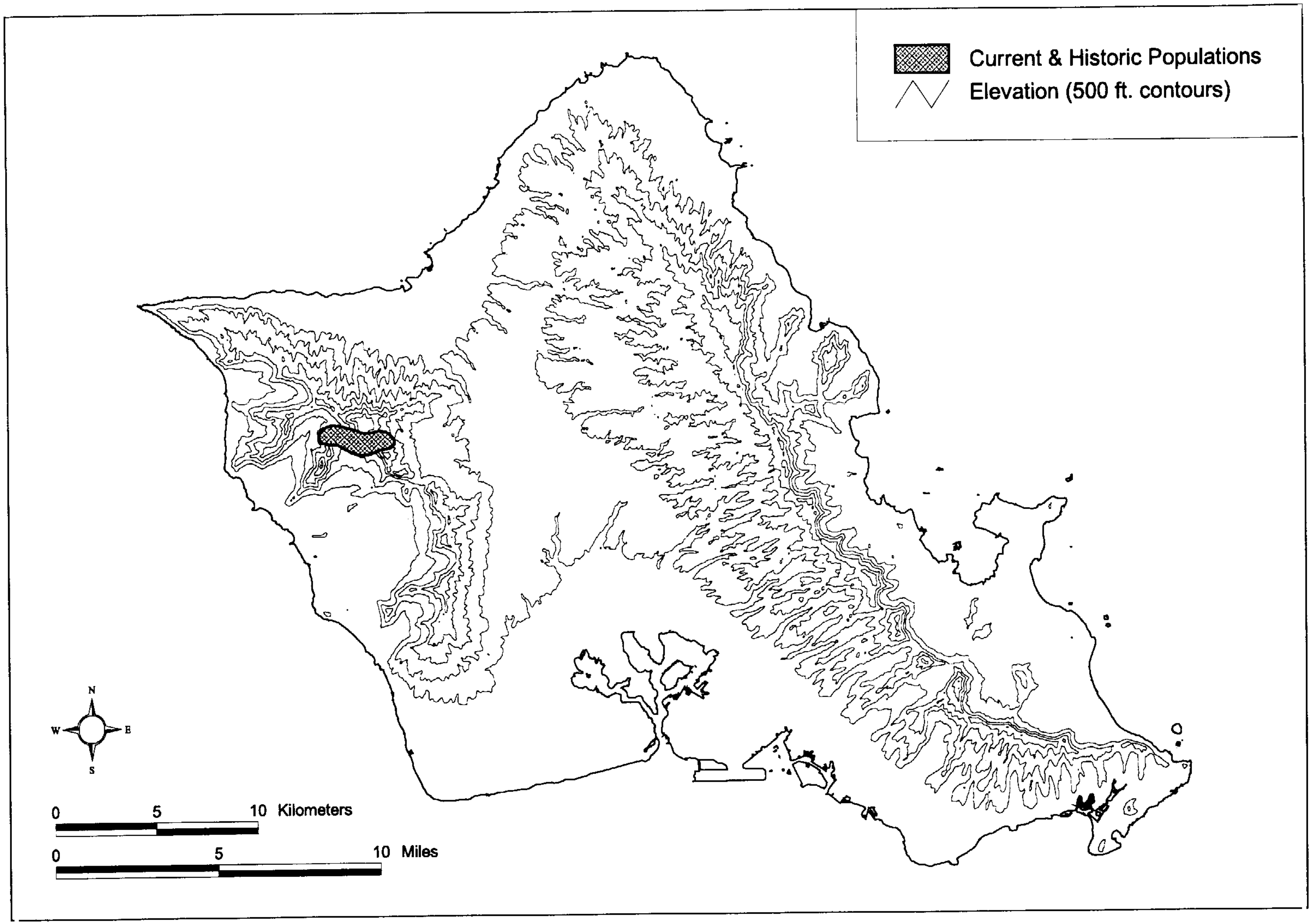
Distribution of *Diellia falcata*



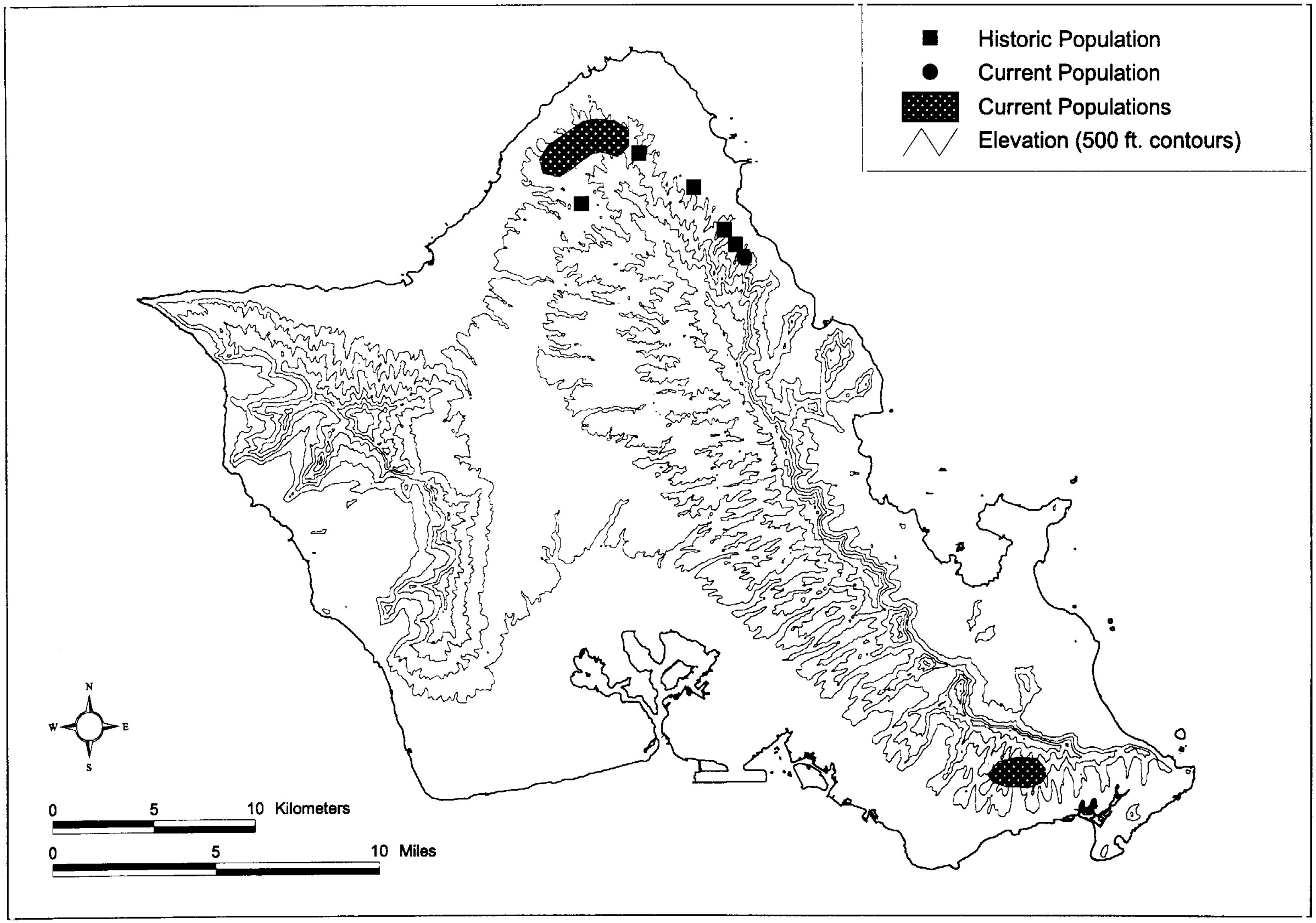
Distribution of *Diellia unisora*



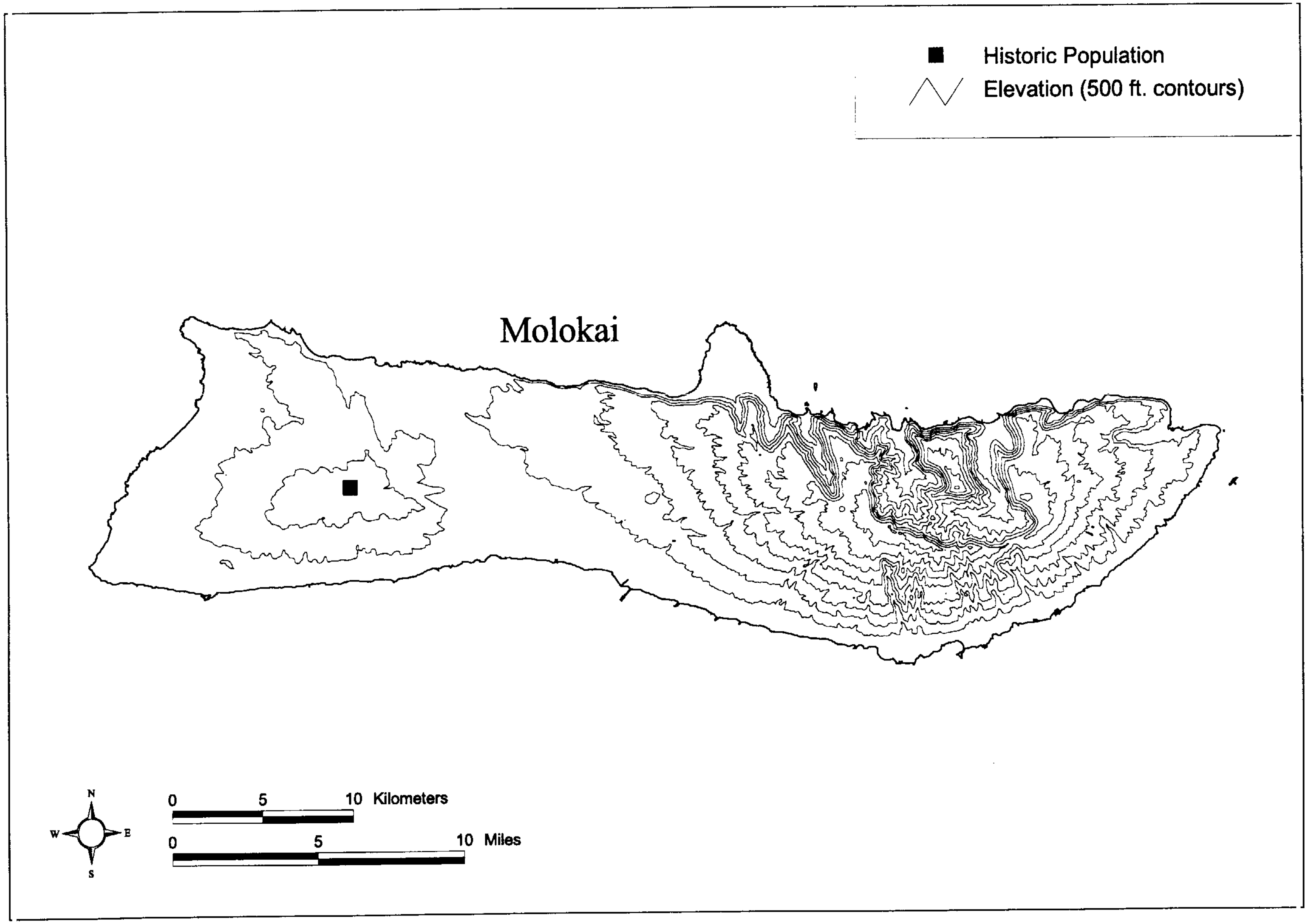
Distribution of *Dubautia herbstobatae*



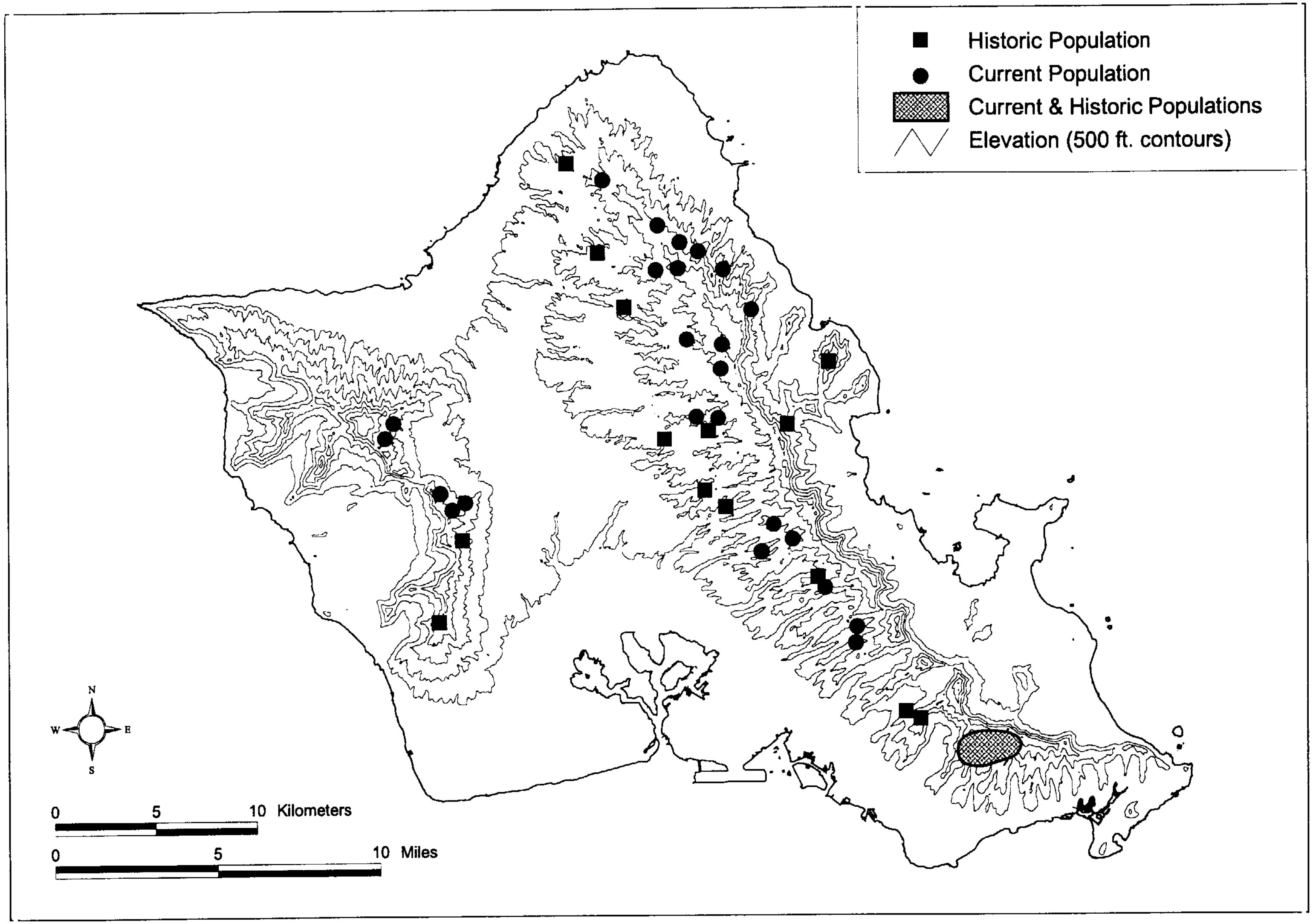
Distribution of *Eragrostis fosbergii*



Distribution of *Eugenia koolauensis* (1 of 2)



Distribution of *Eugenia koolauensis* (2 of 2)



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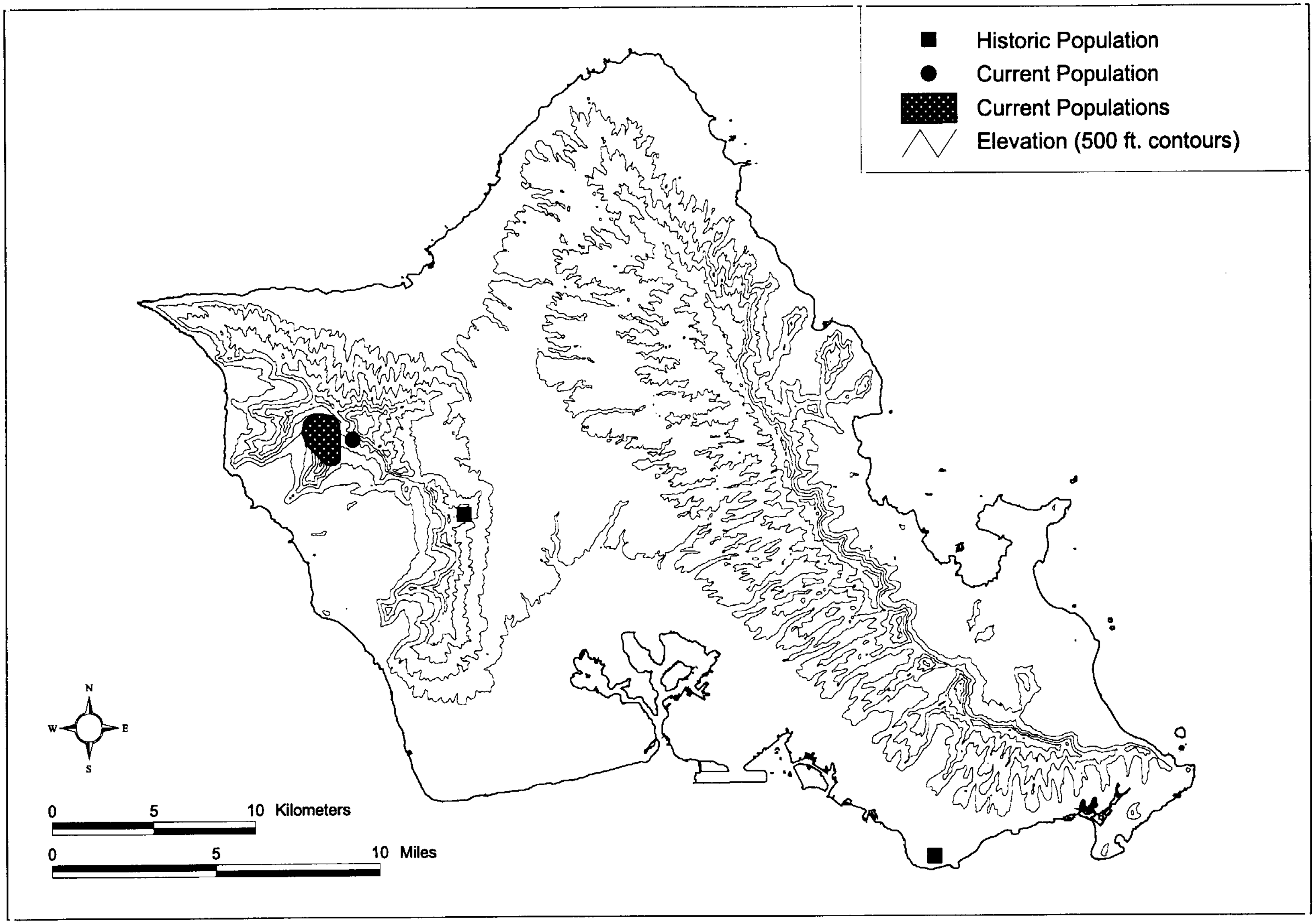

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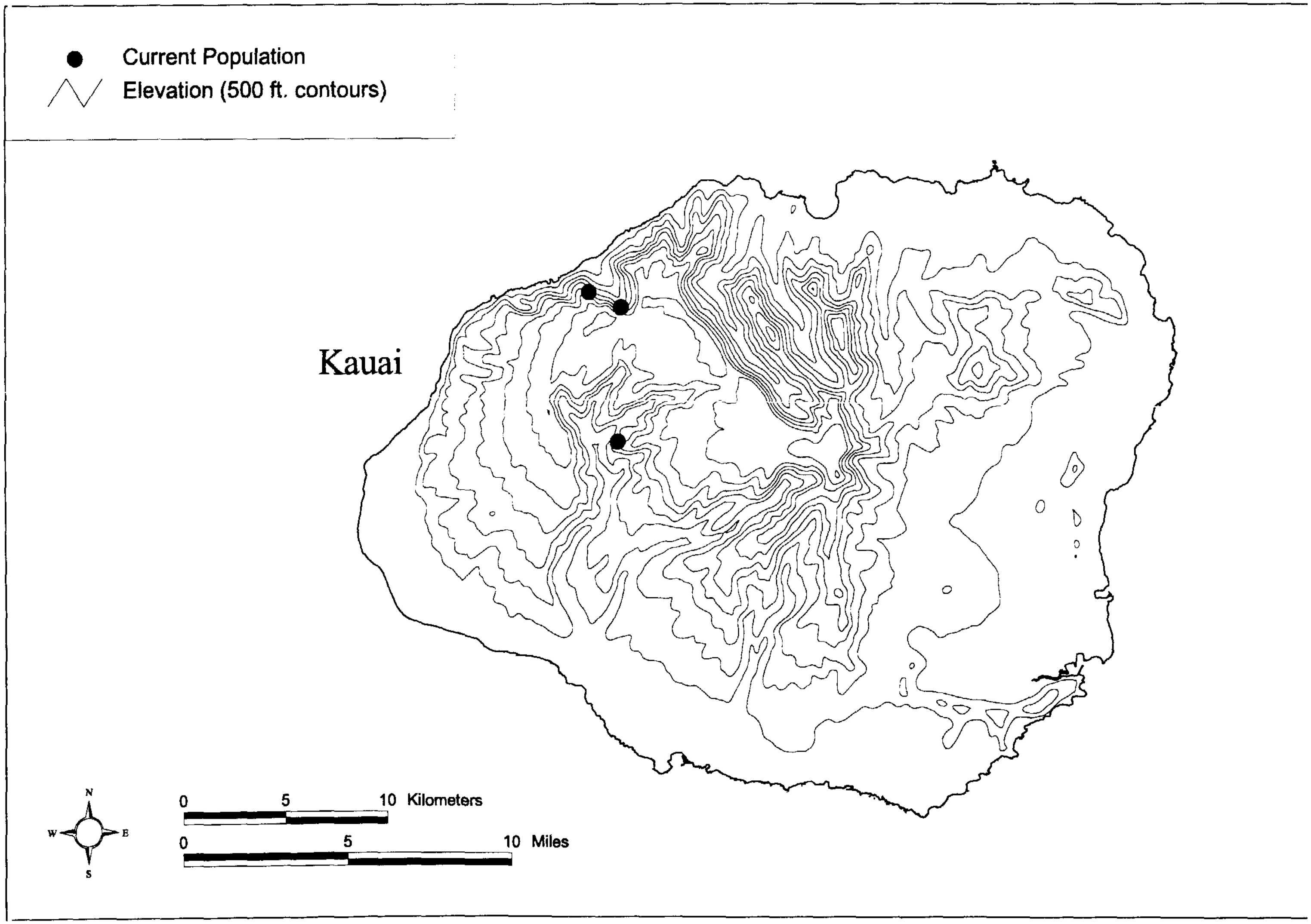

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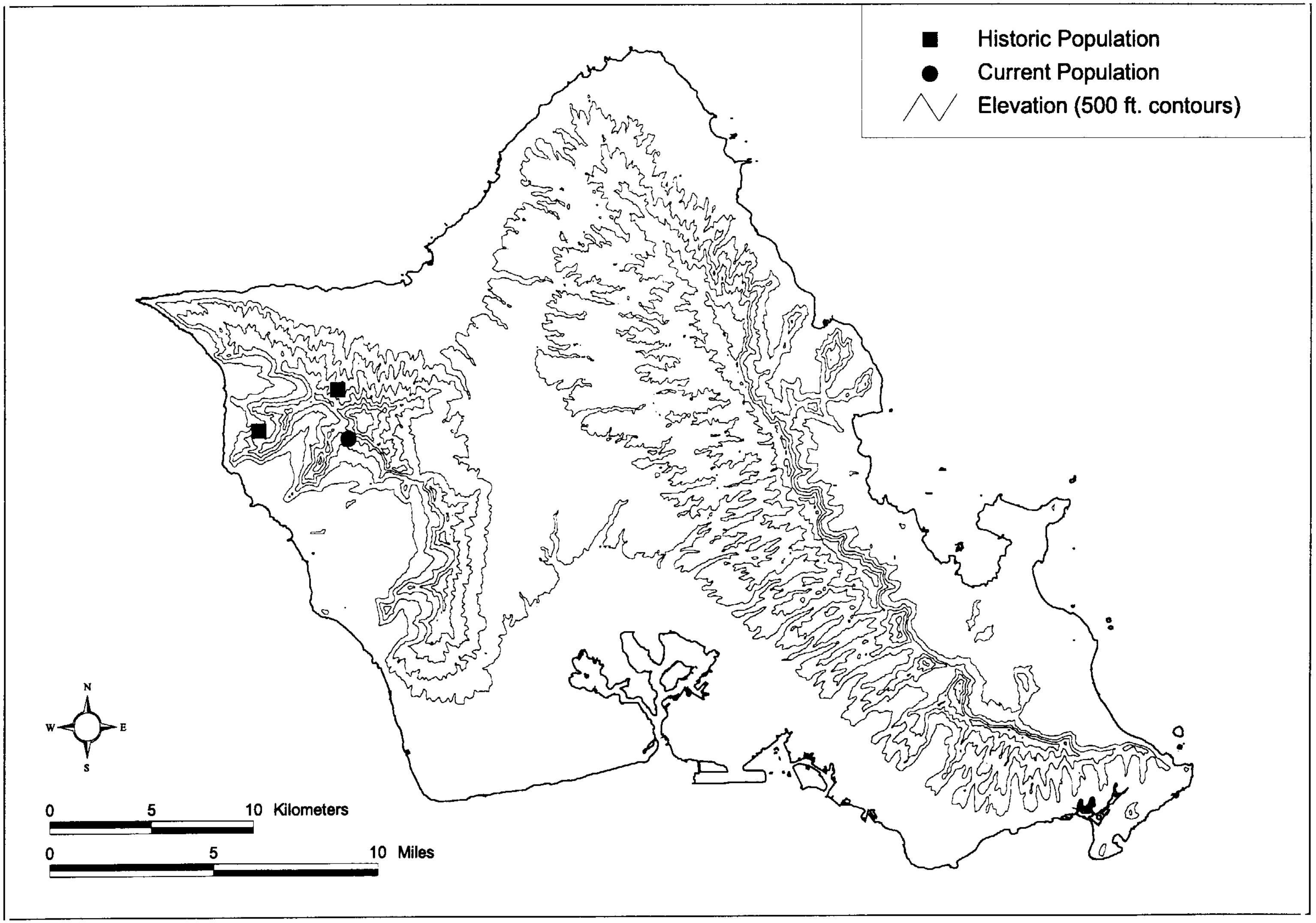

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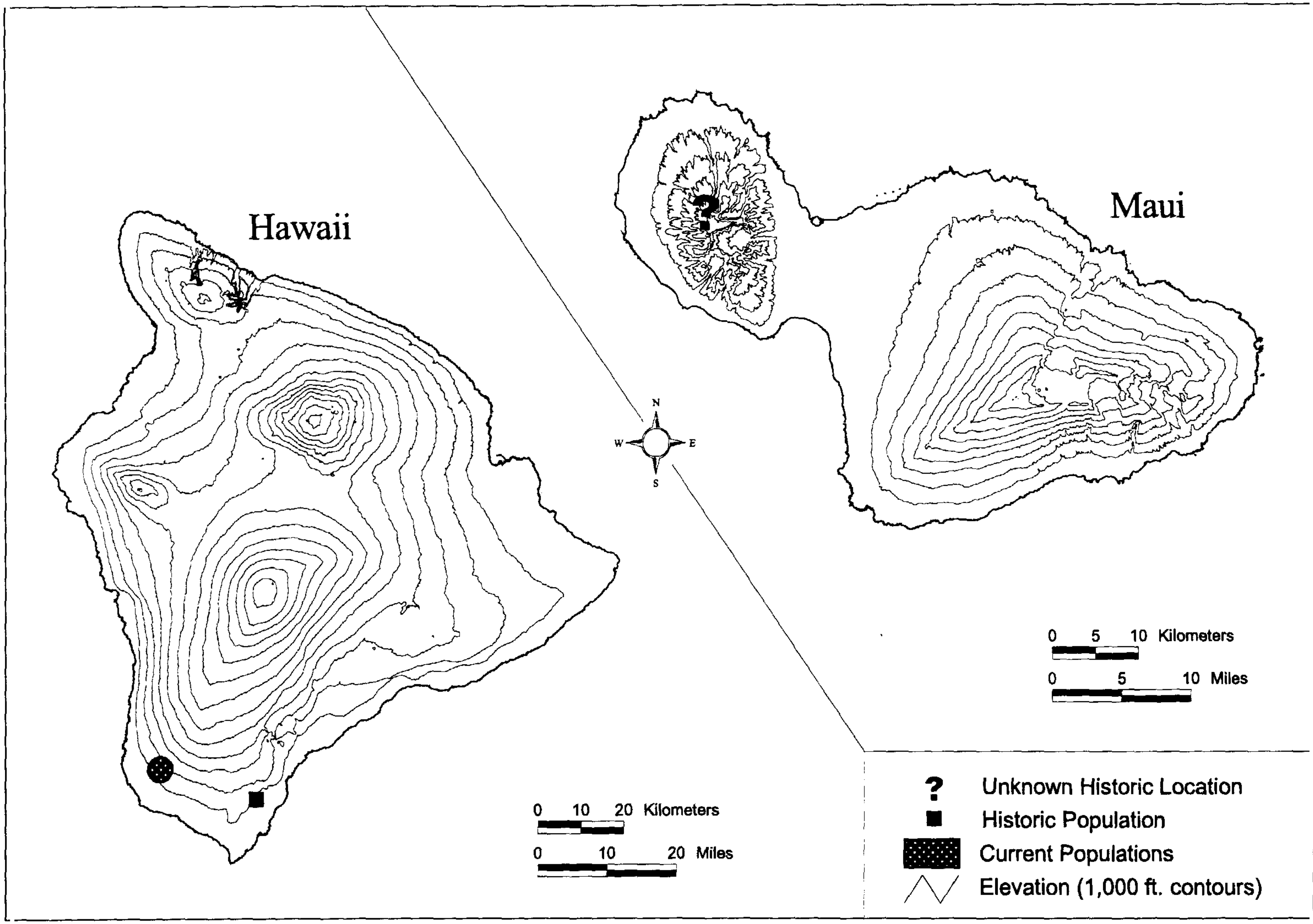

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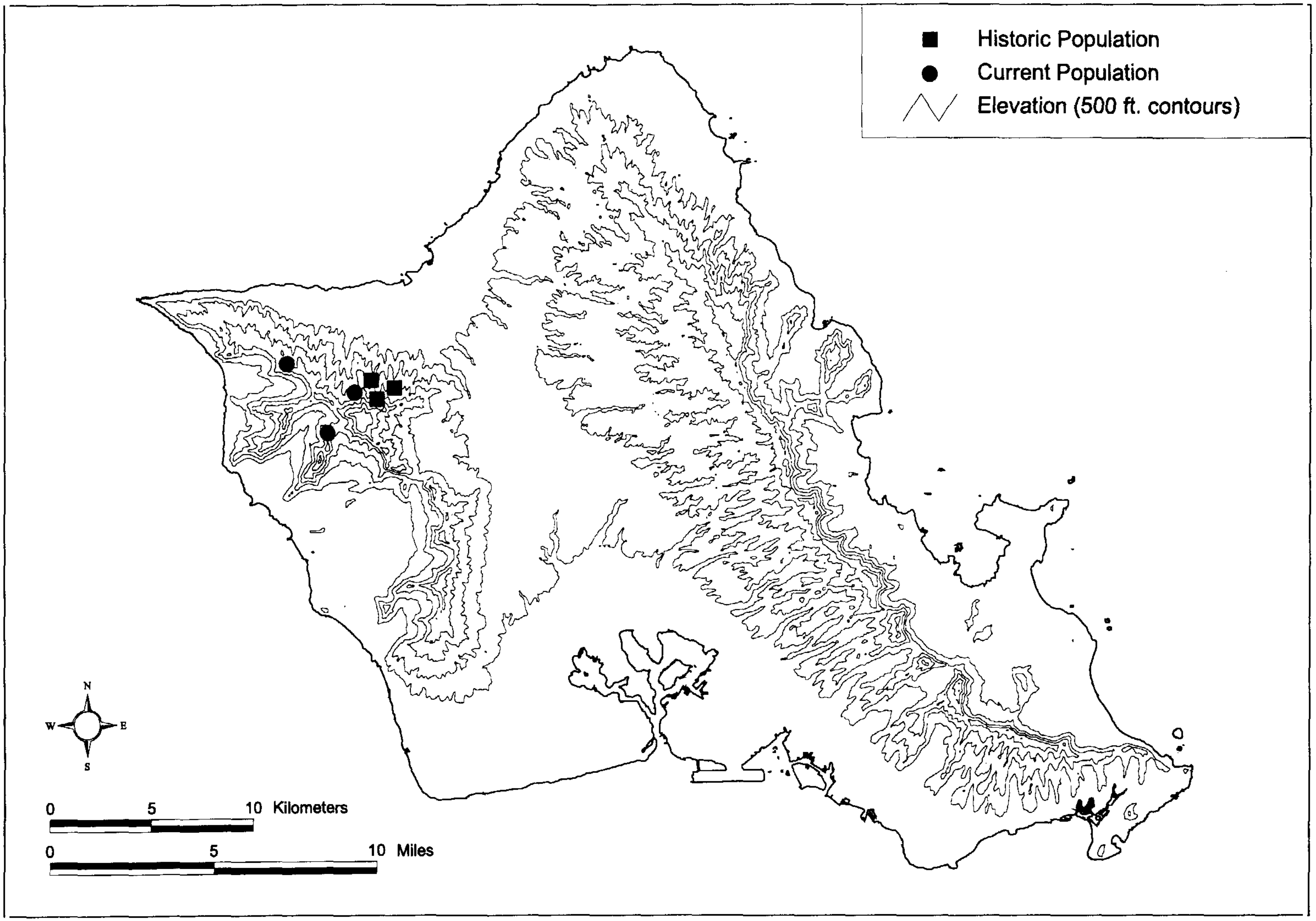

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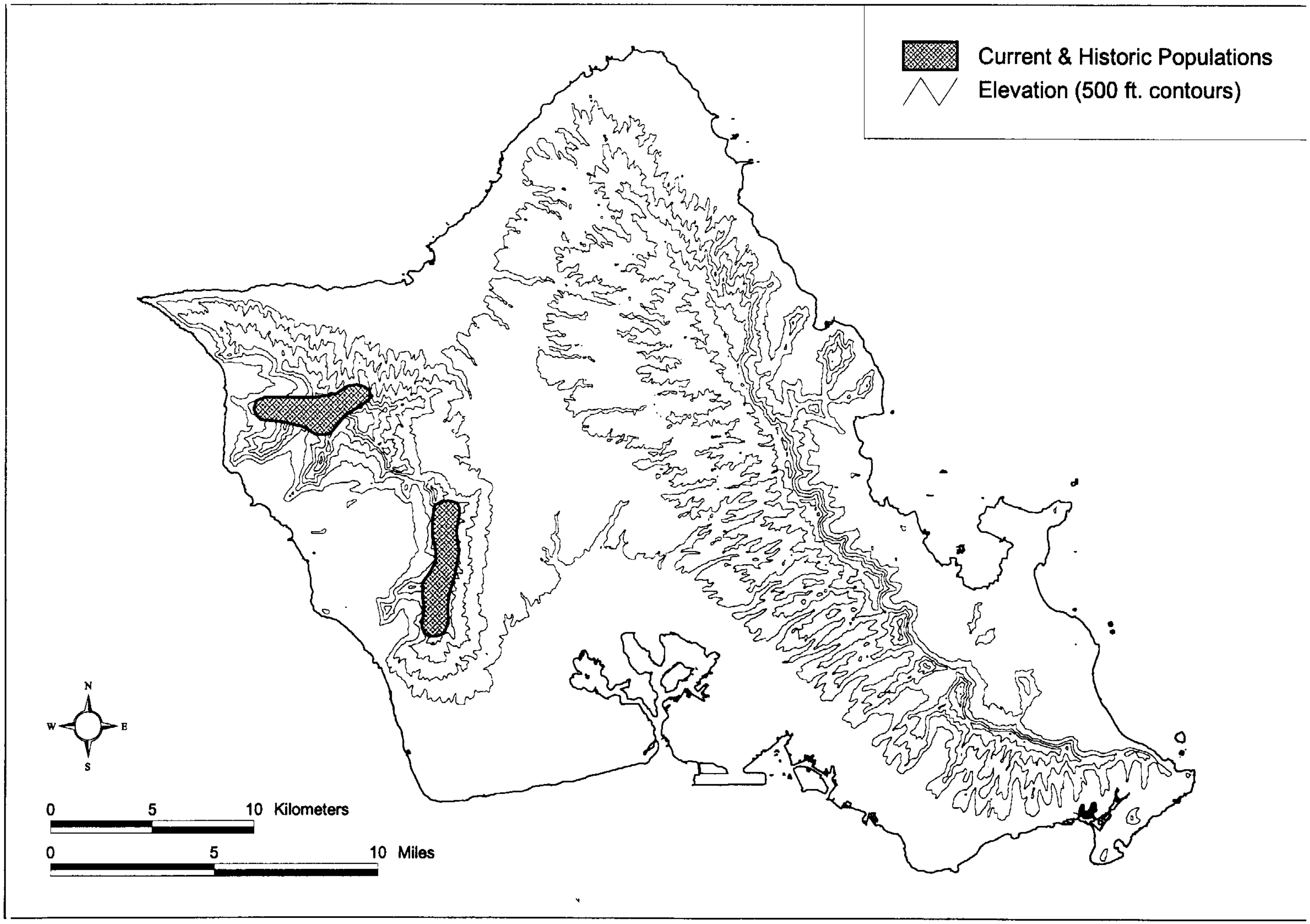

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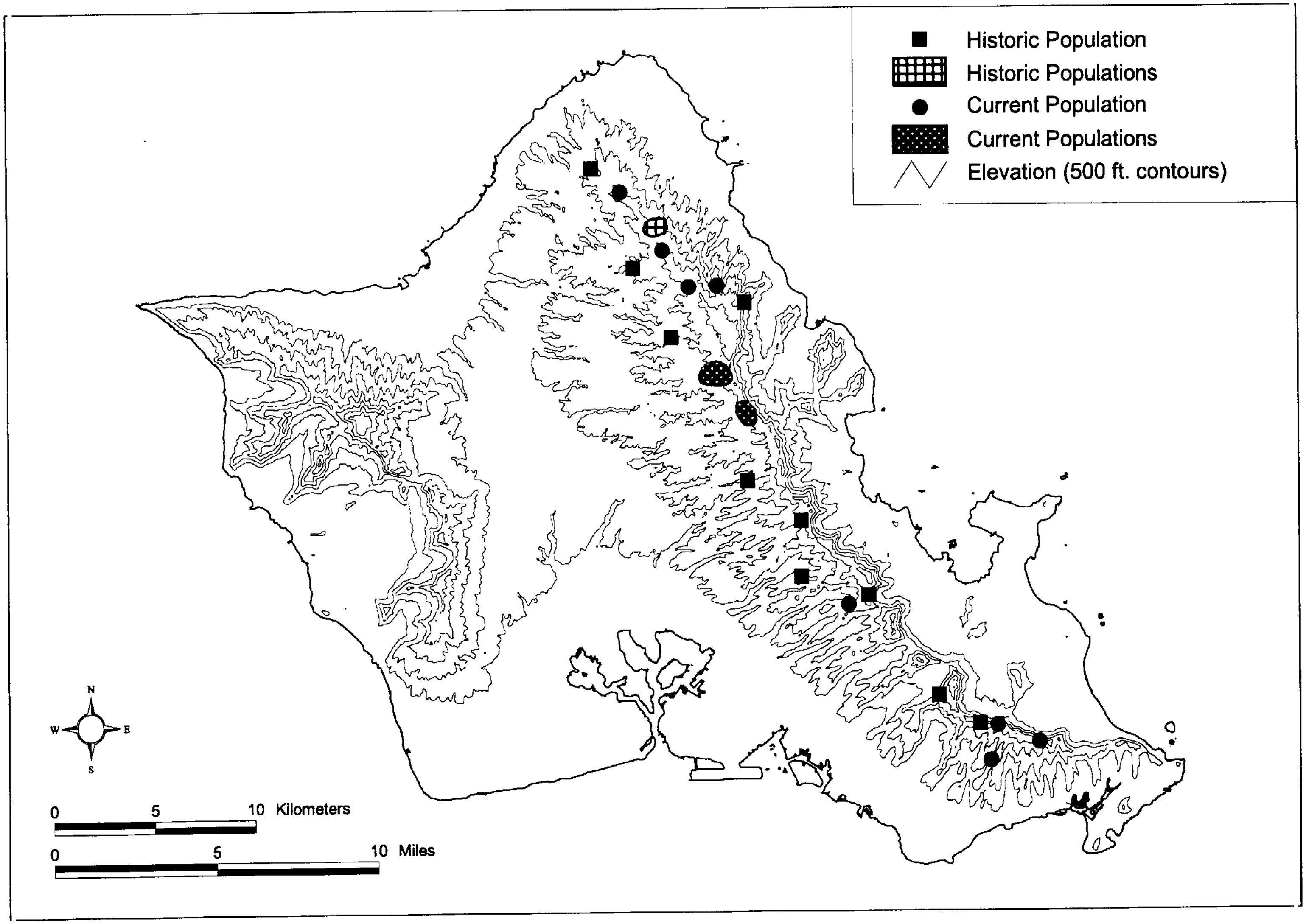
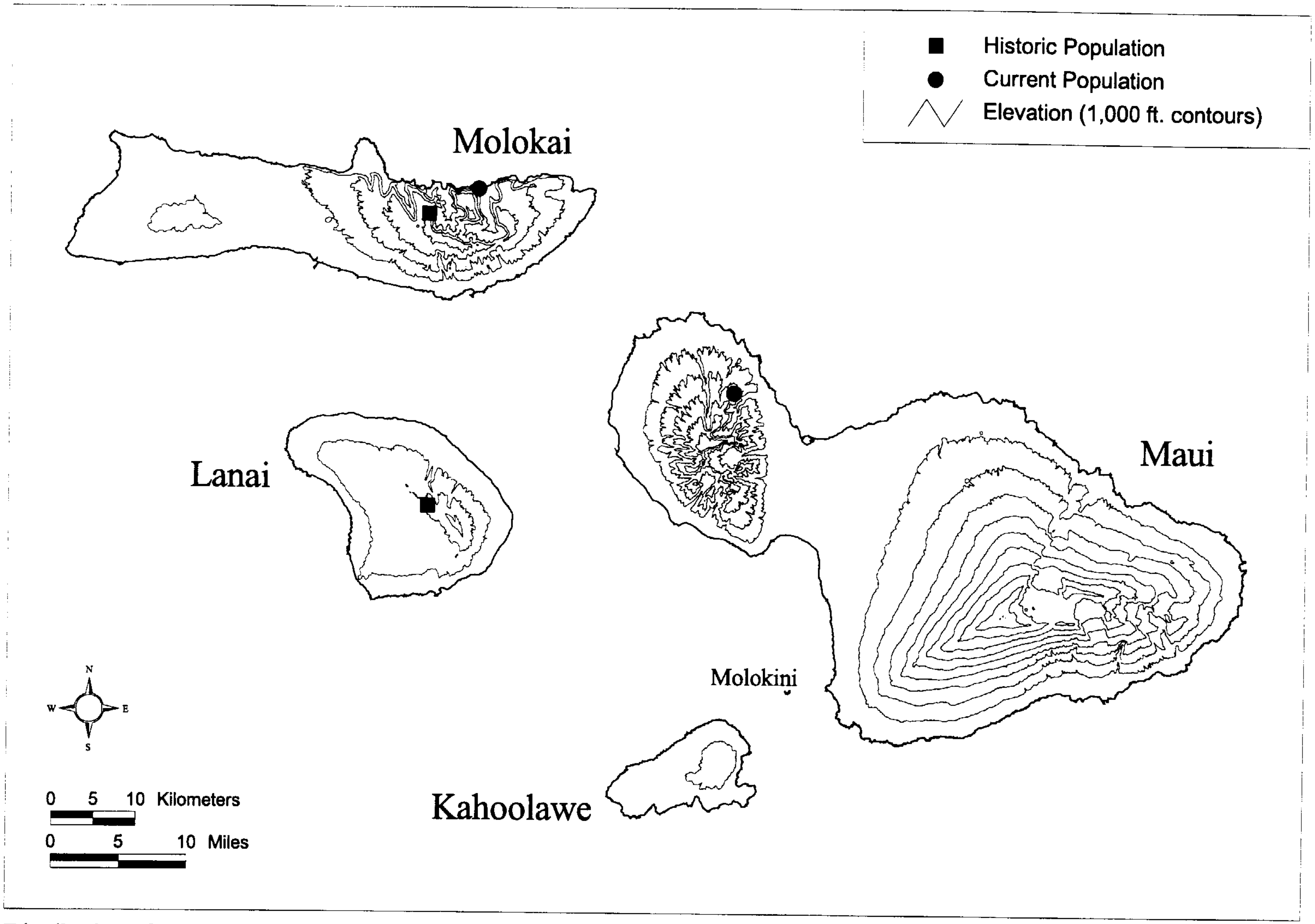


Distribution of *Hesperomannia arborescens* (1 of 2)



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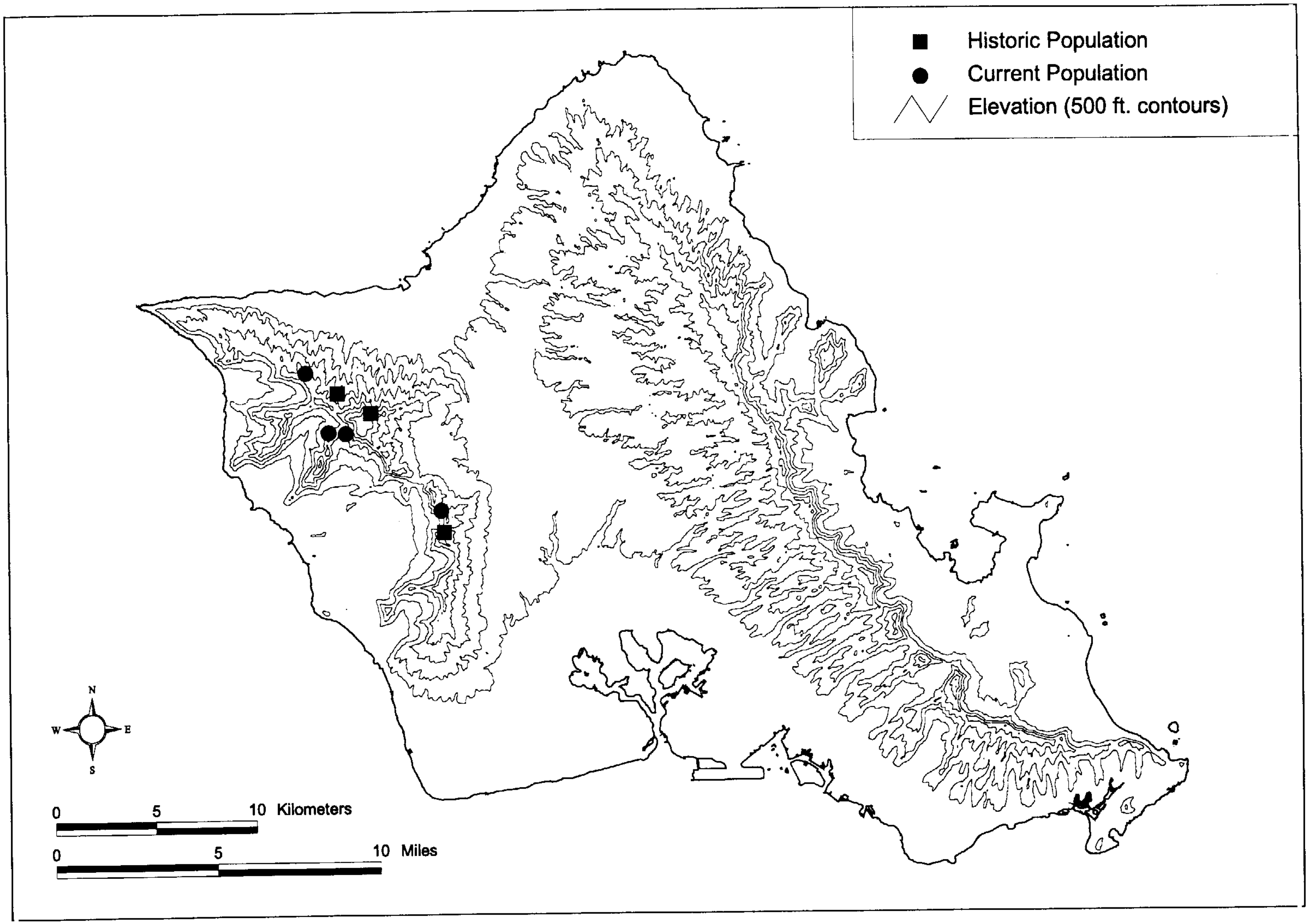

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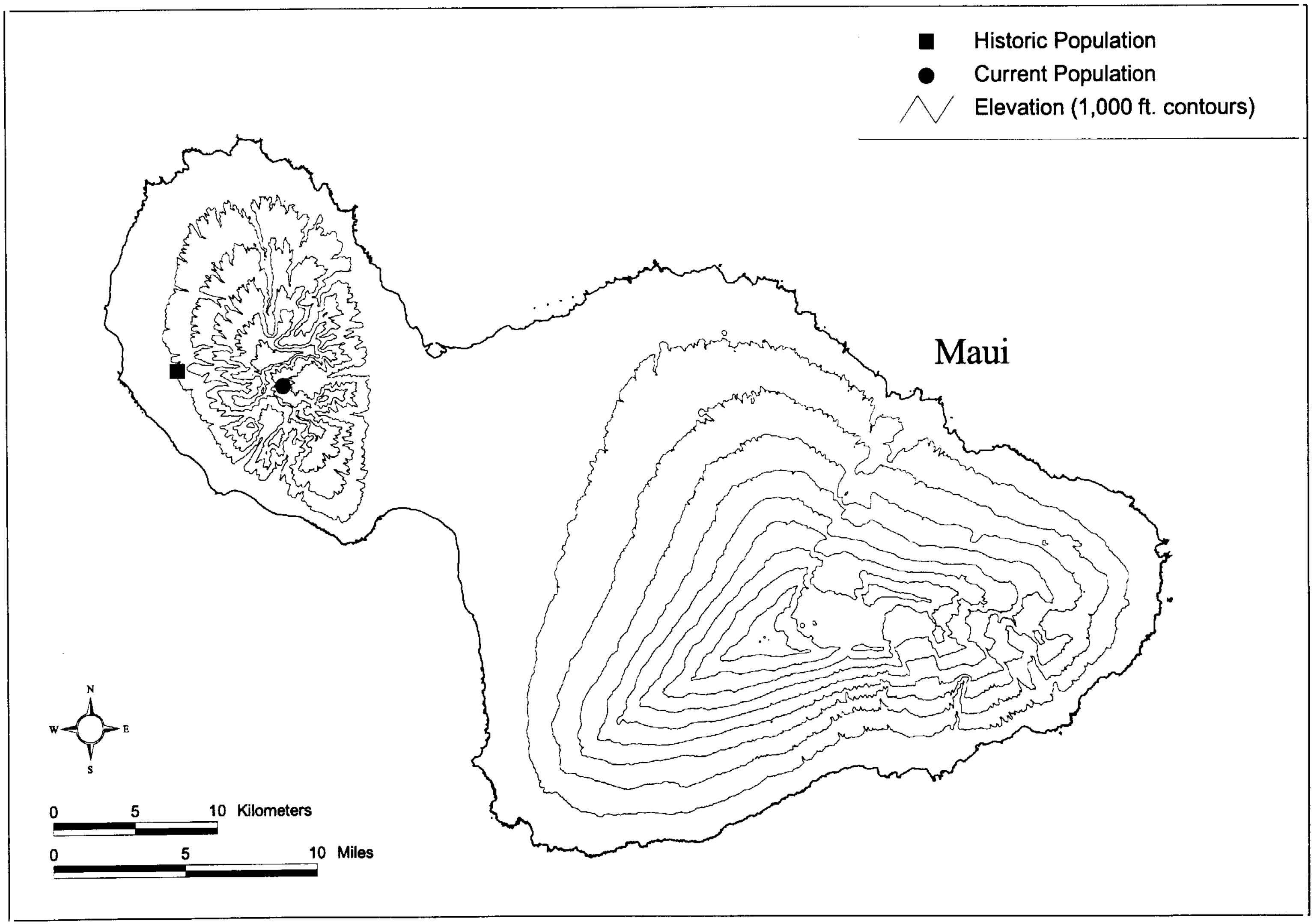

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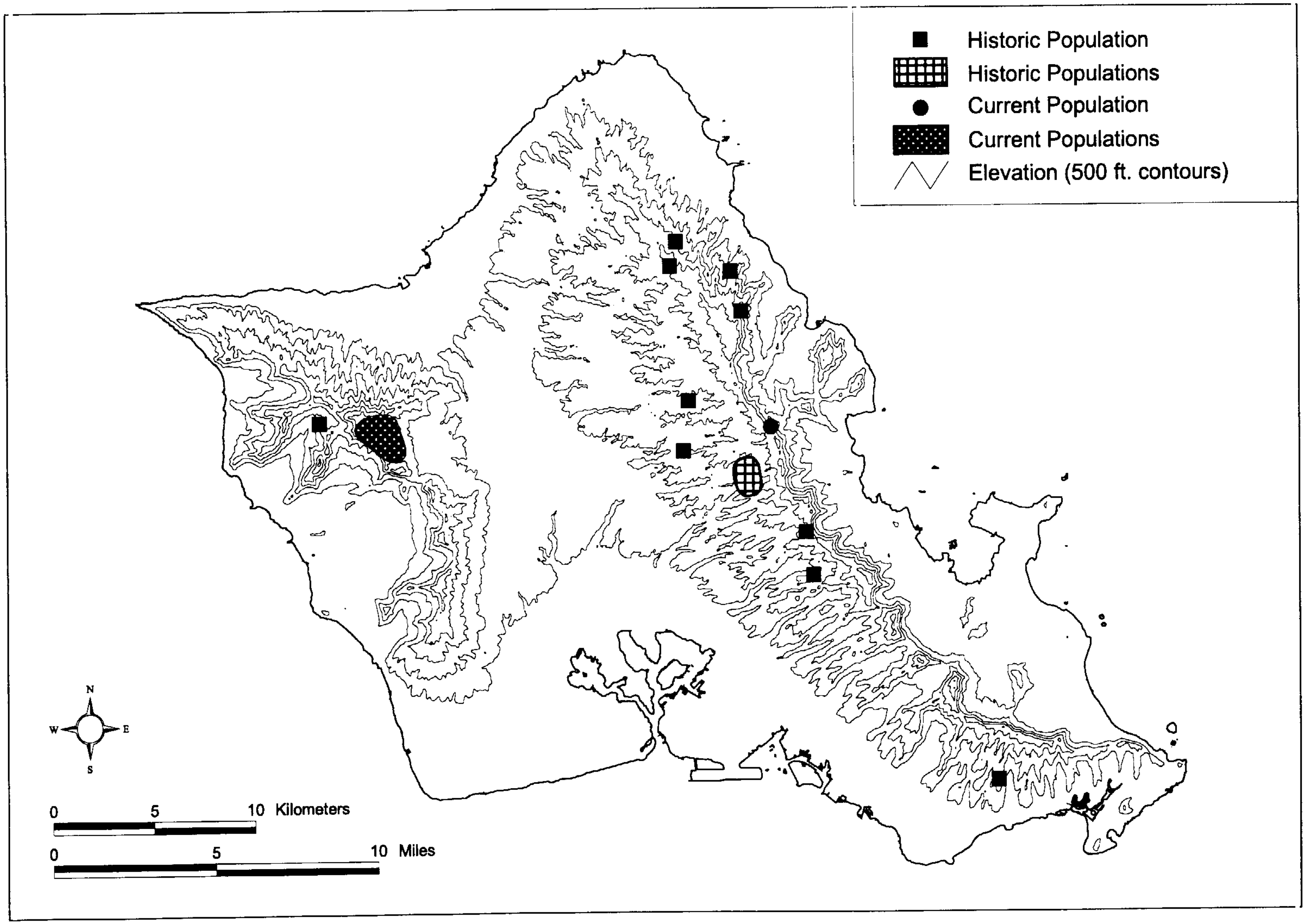

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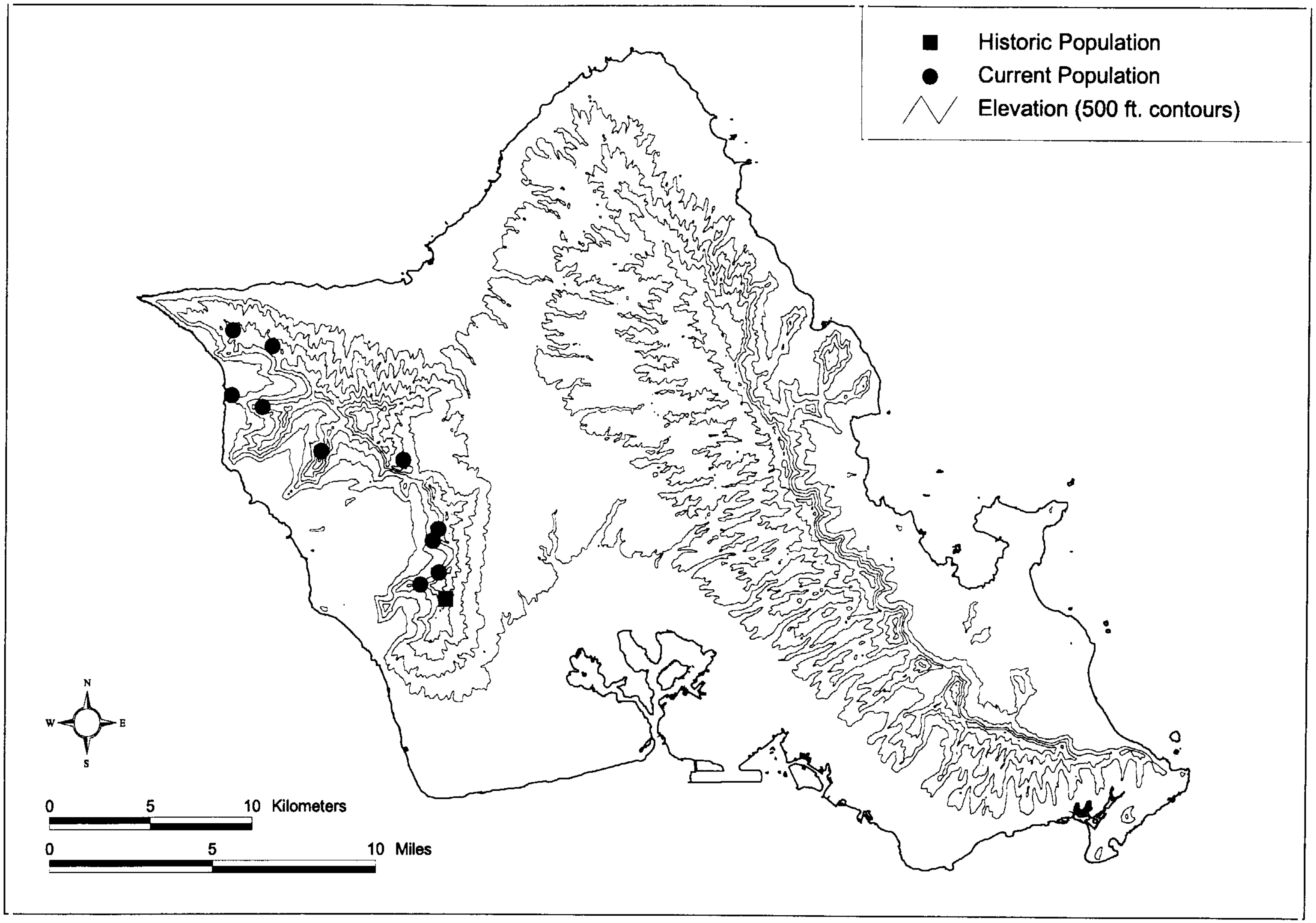

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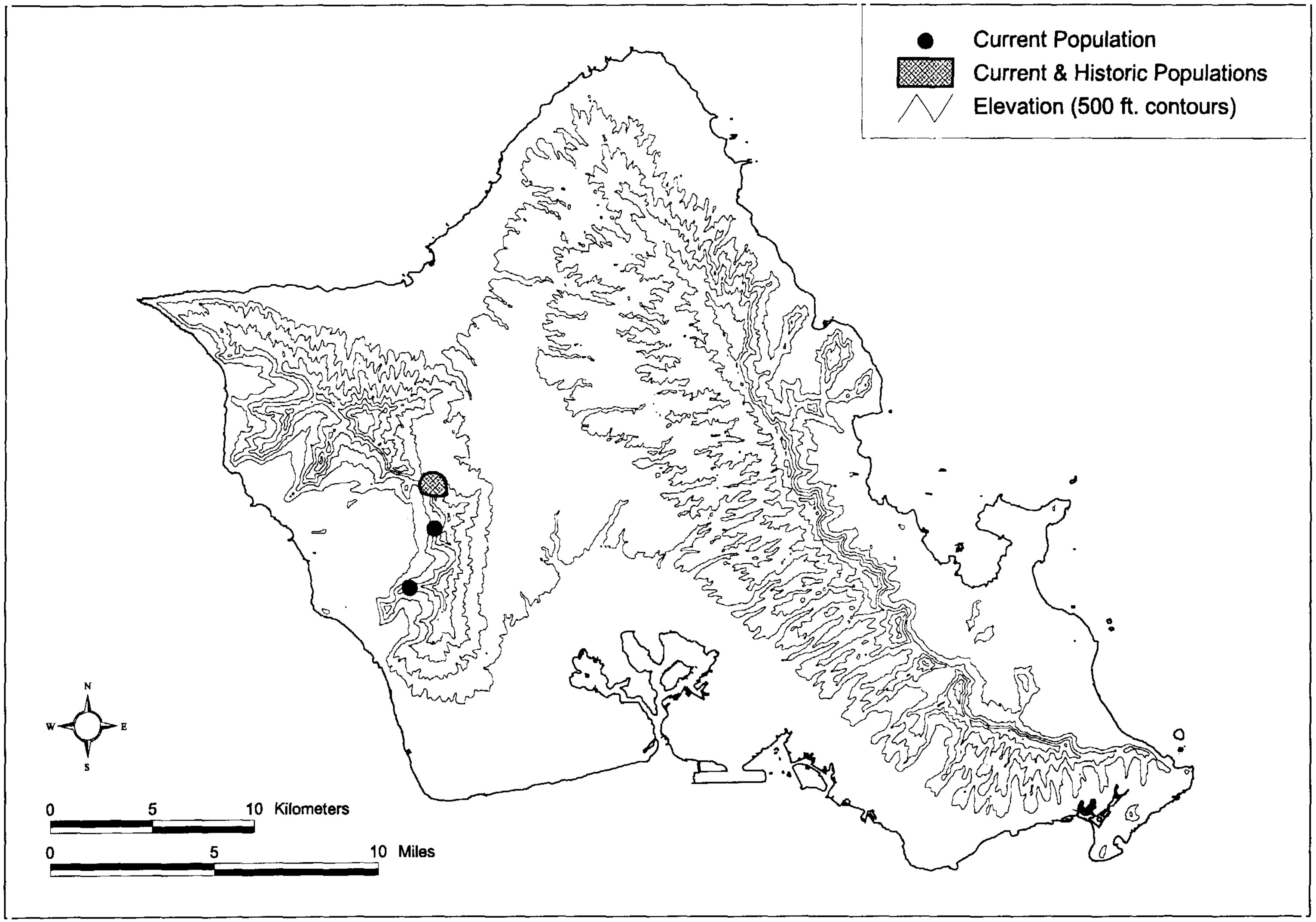

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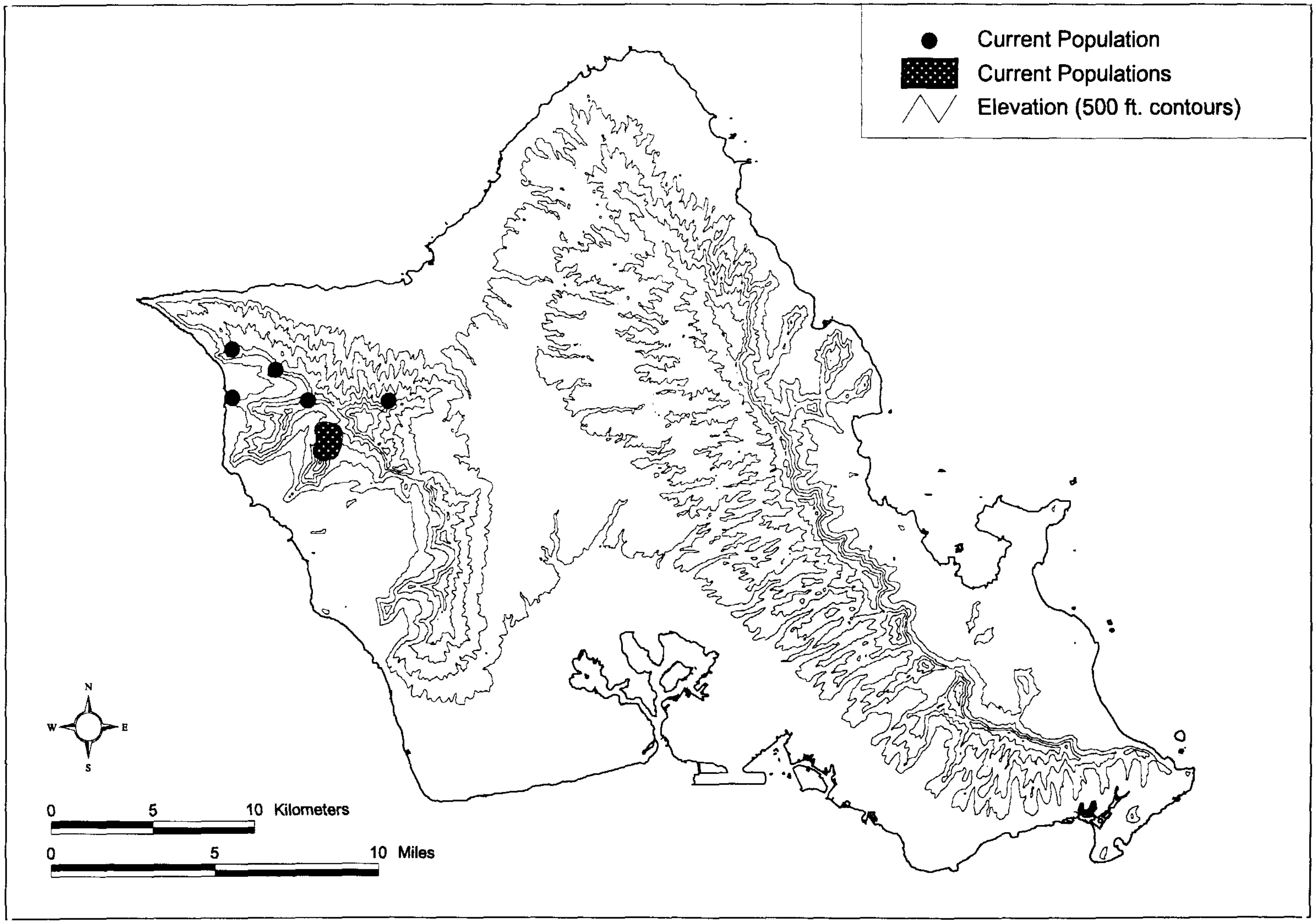

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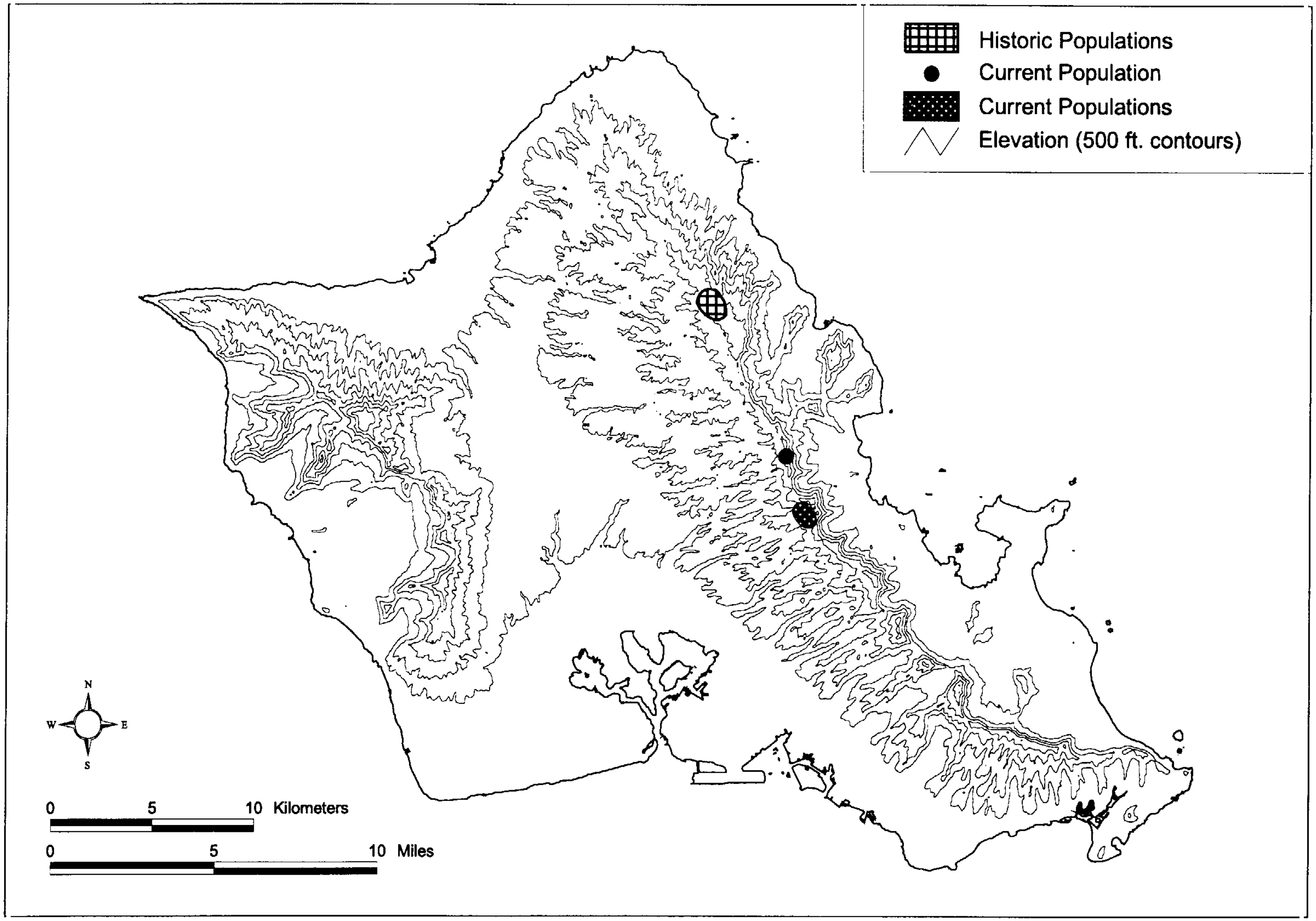

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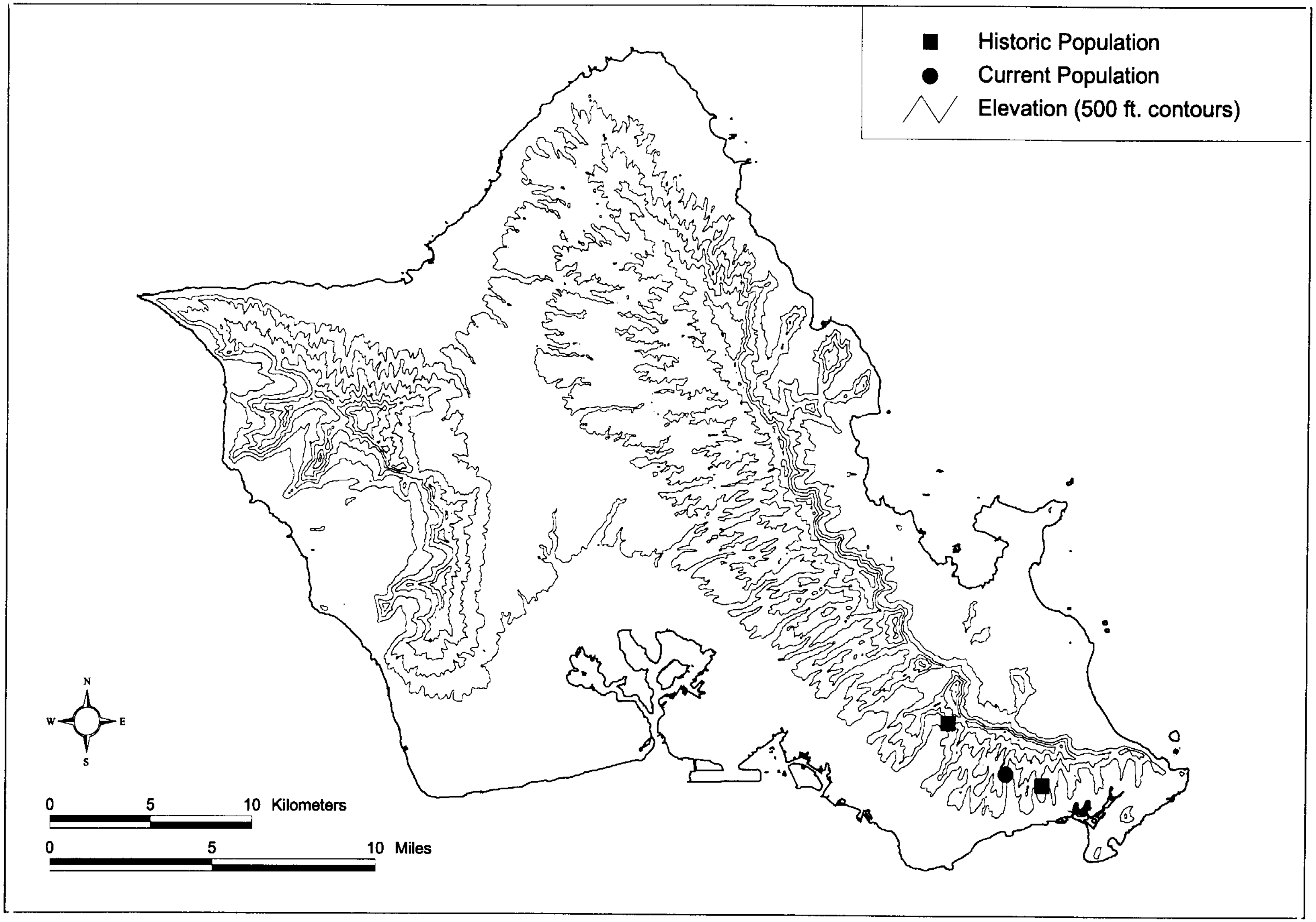

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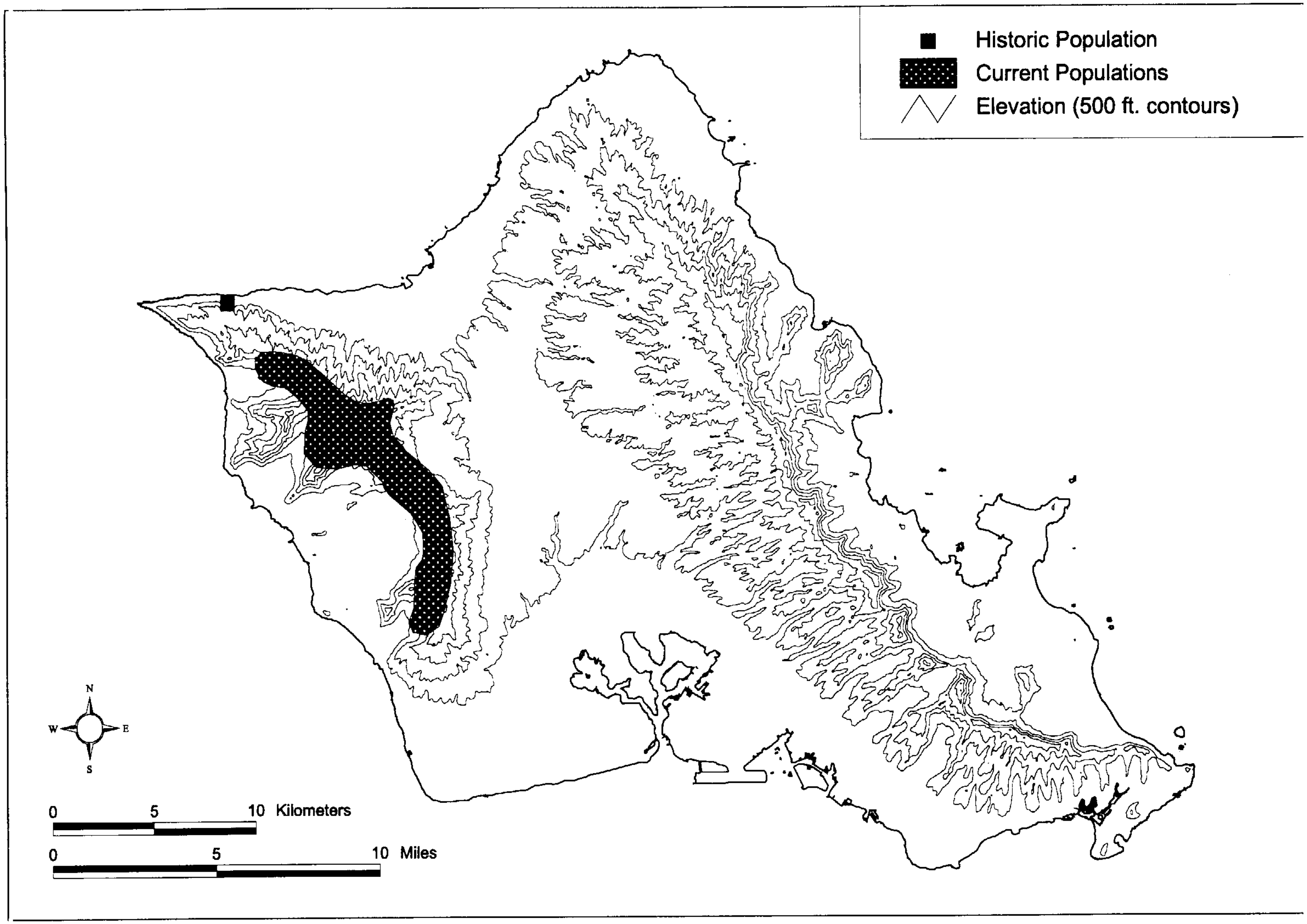
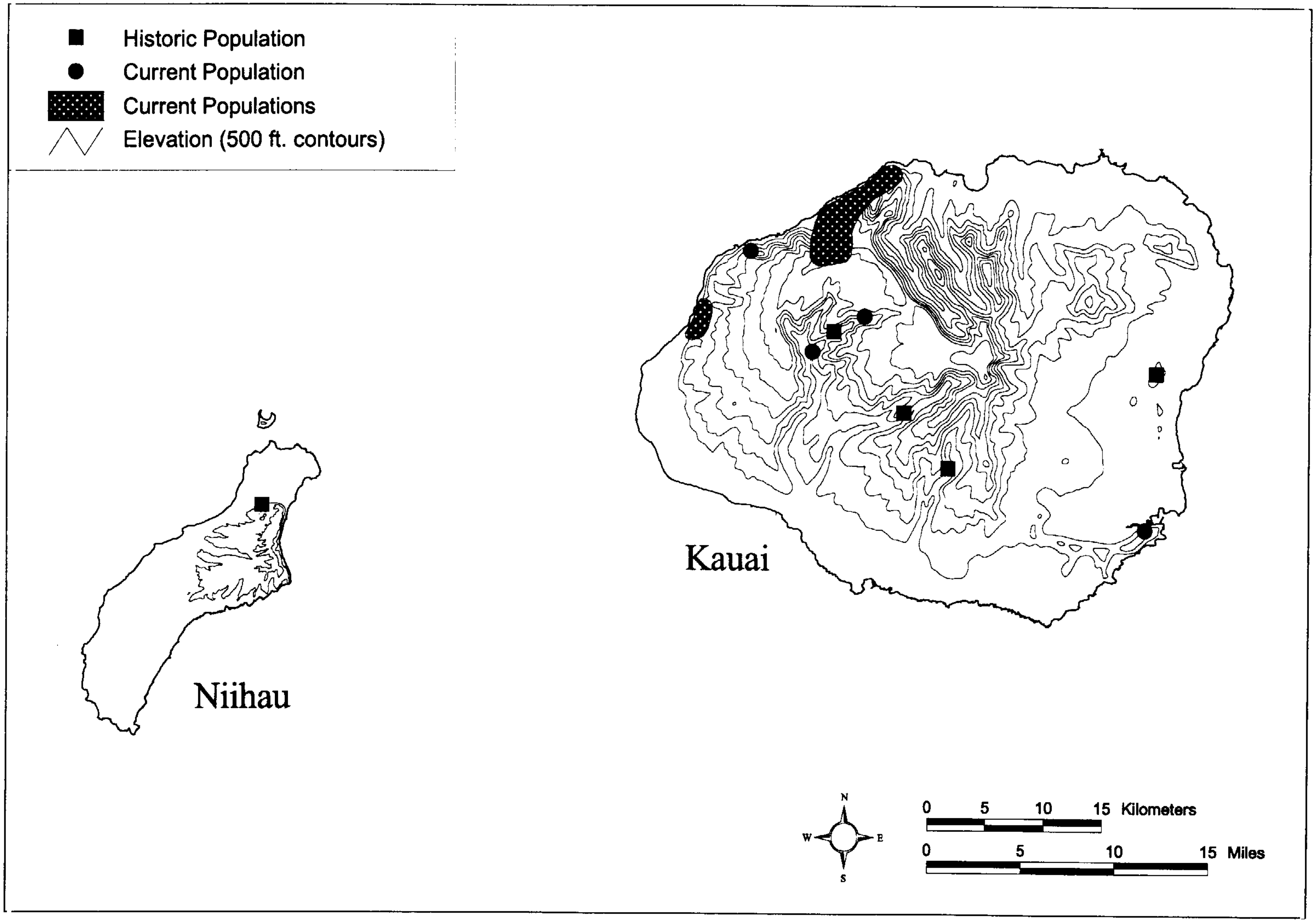
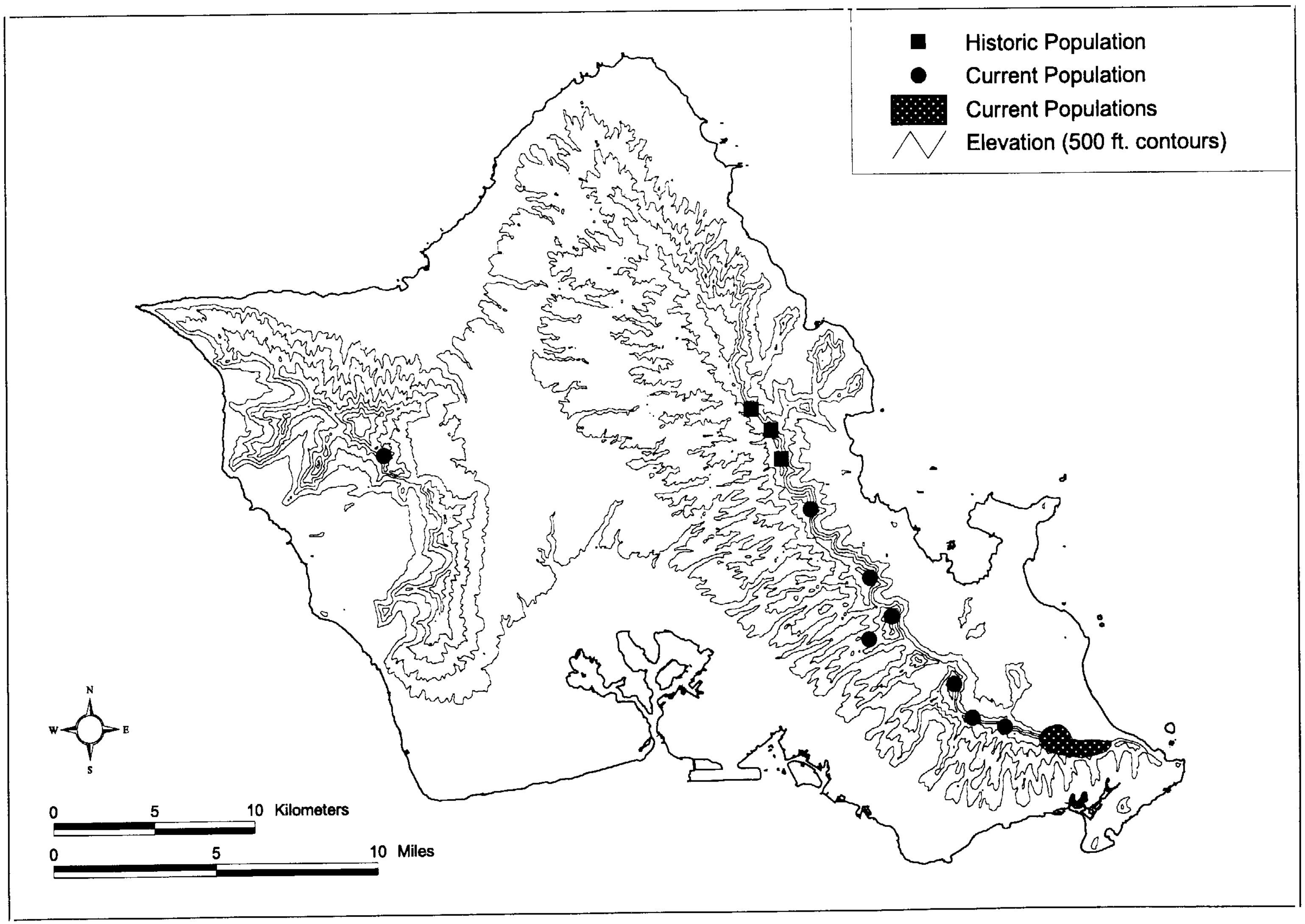


Distribution of *Lobelia niihauensis* (1 of 2)



Distribution of *Lobelia niihauensis* (2 of 2)



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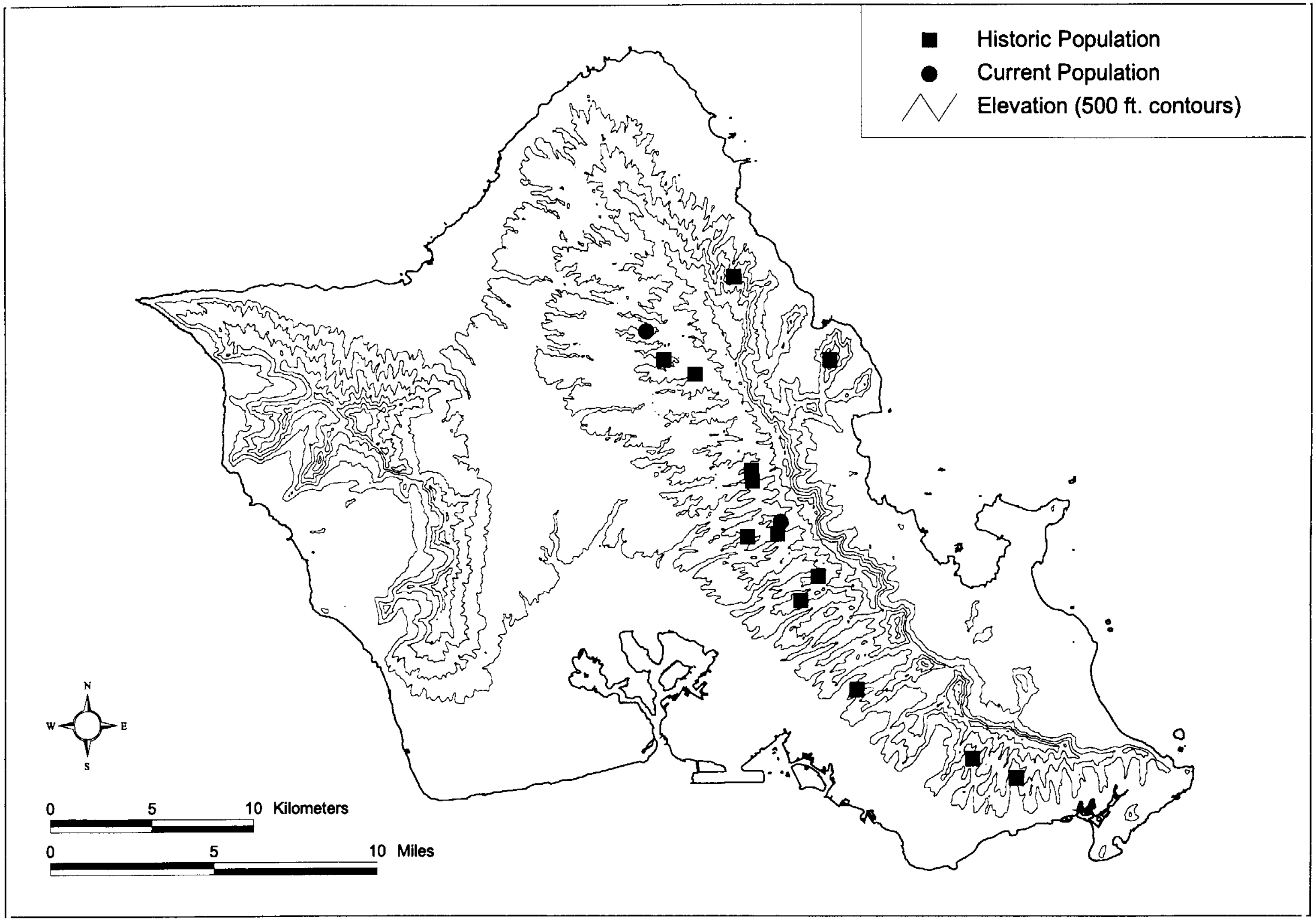
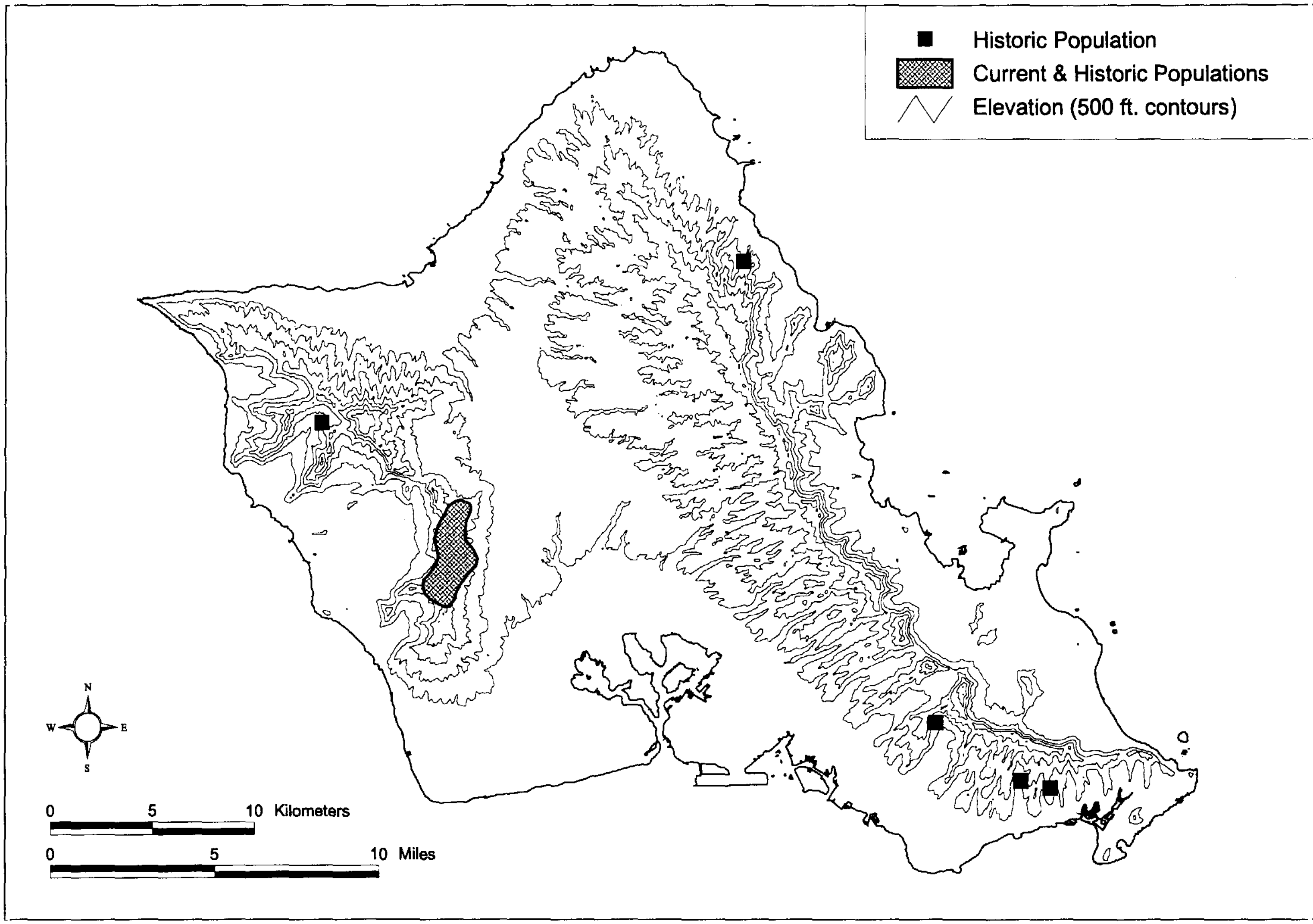


Distribution of *Melicope lydgatei*



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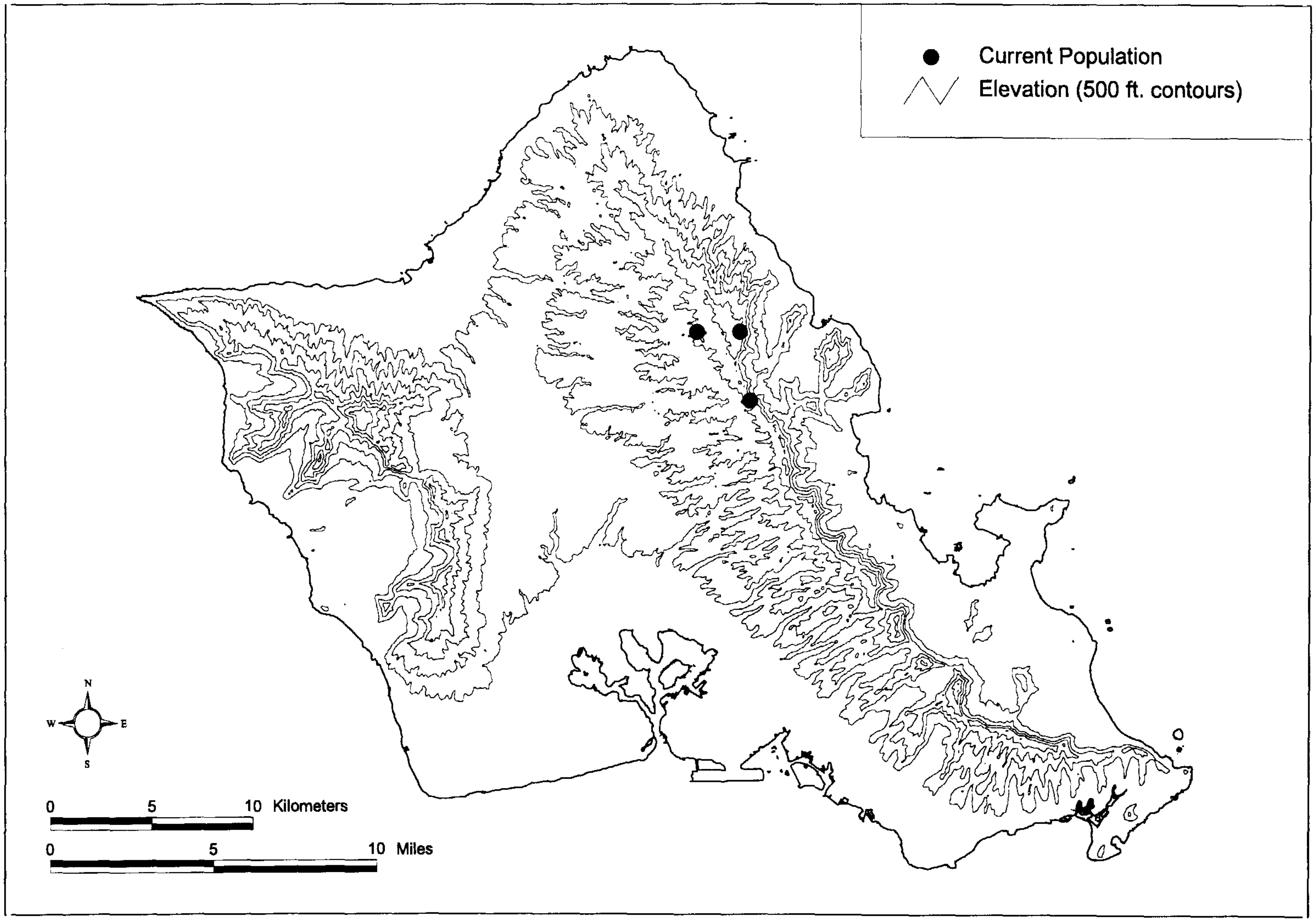

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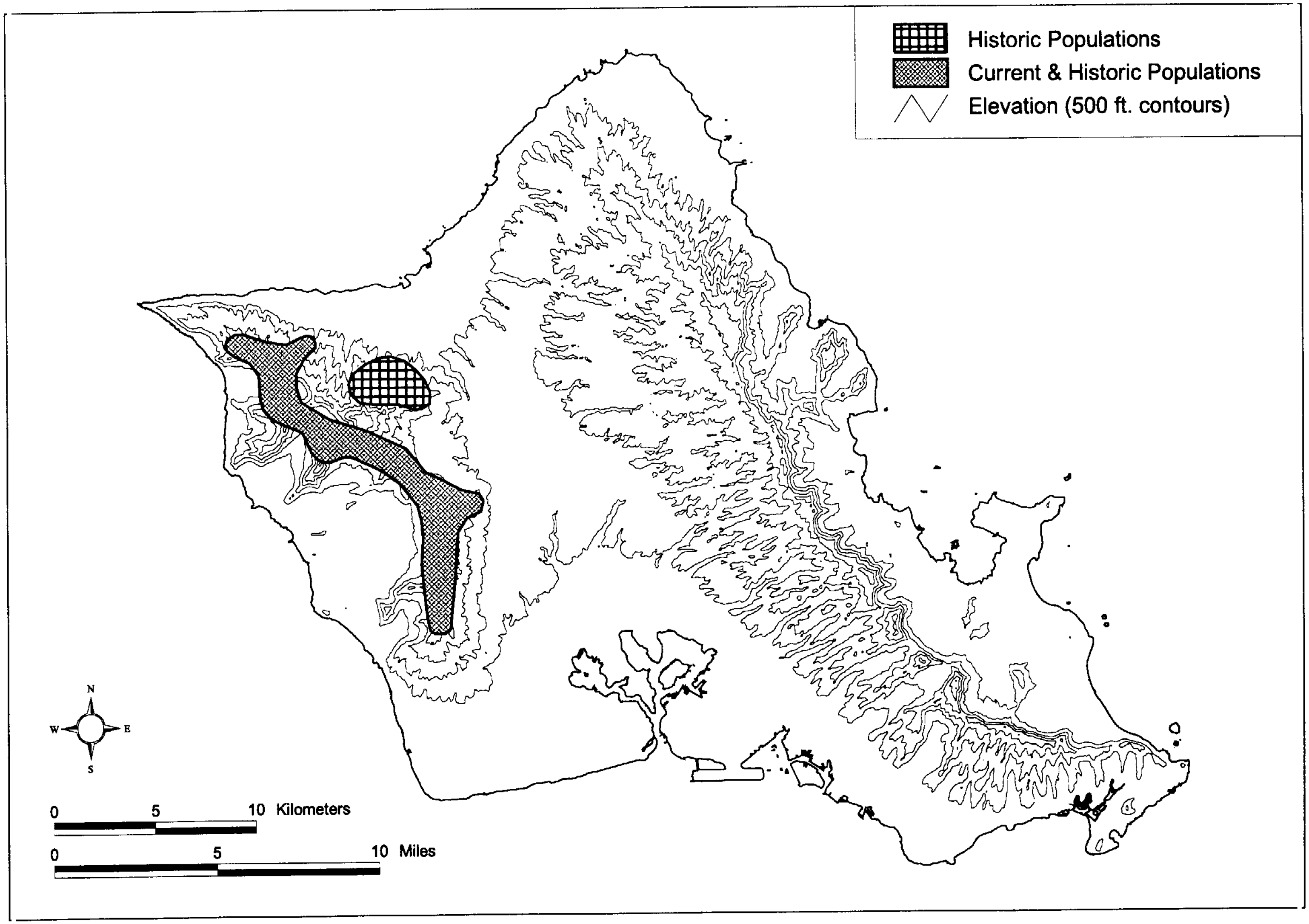

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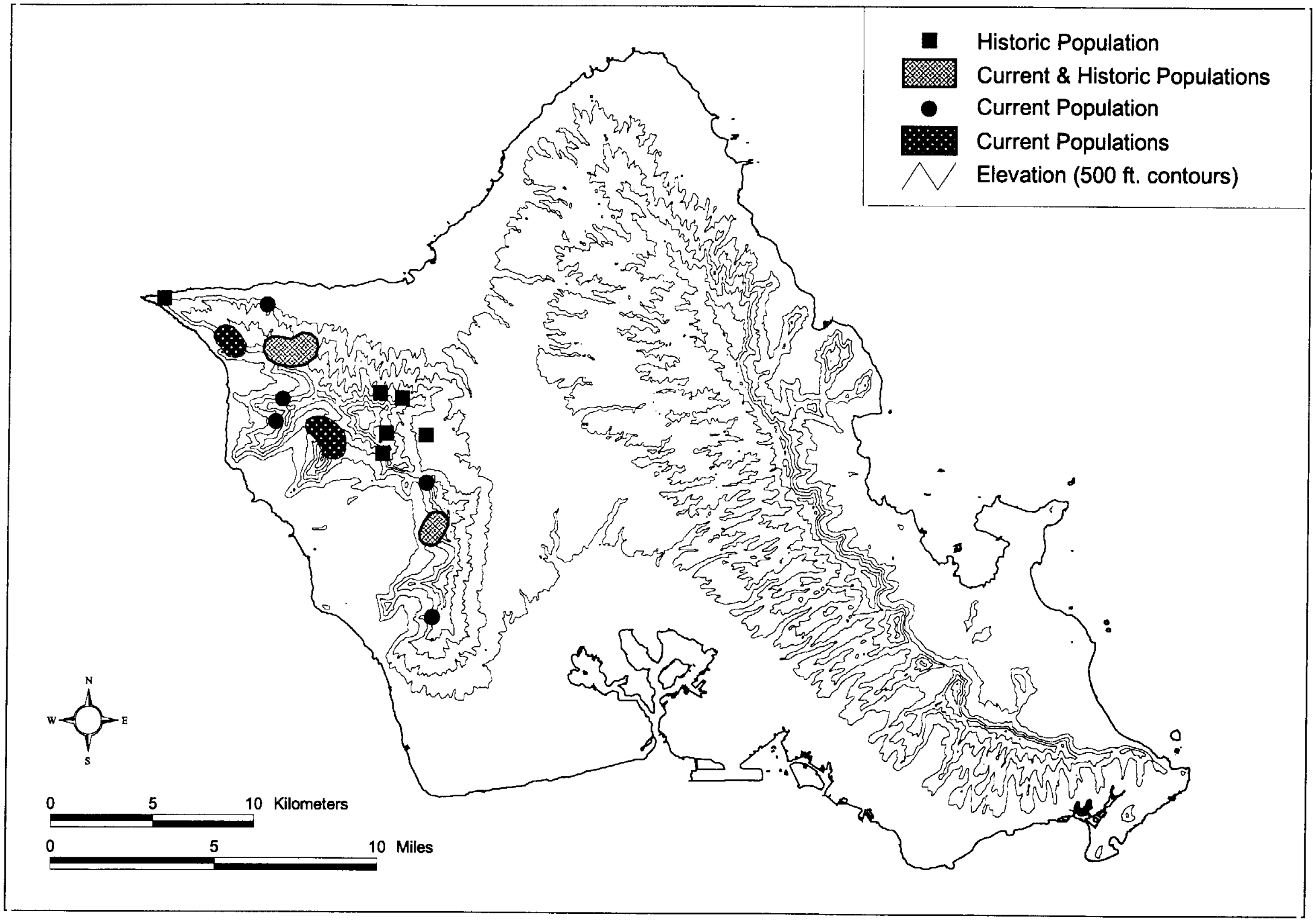
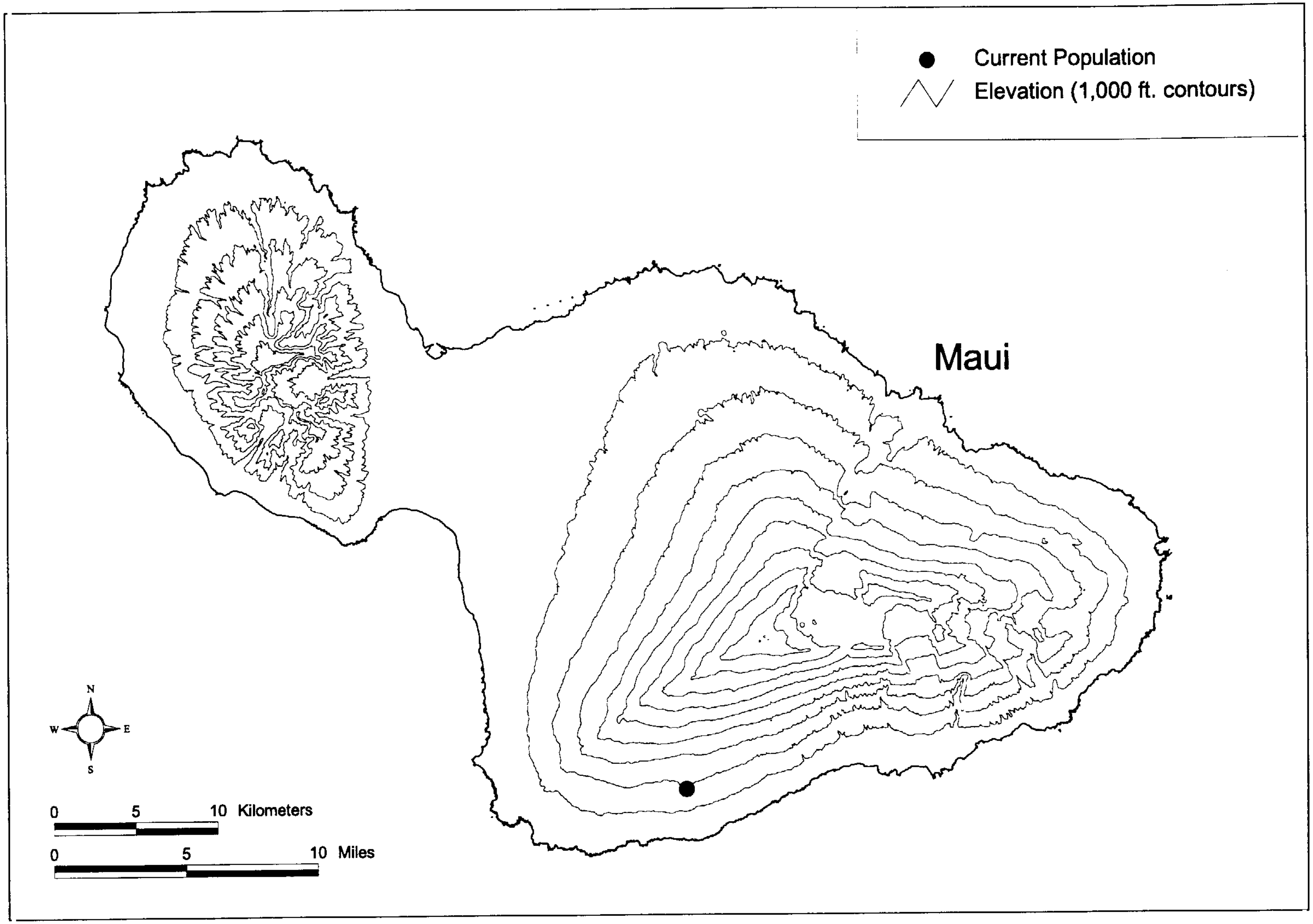


Distribution of *Nototrichium humile* (1 of 2)



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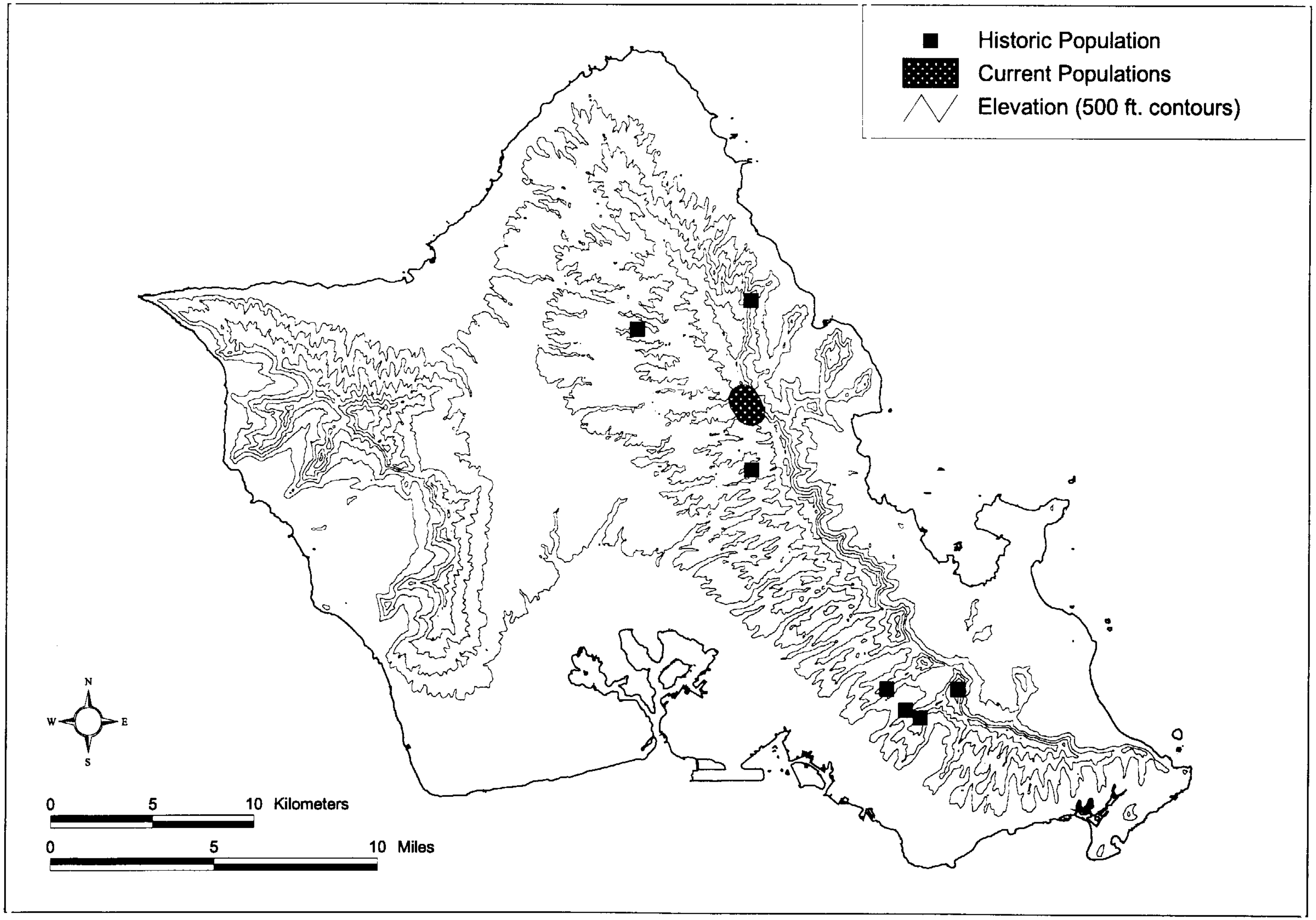
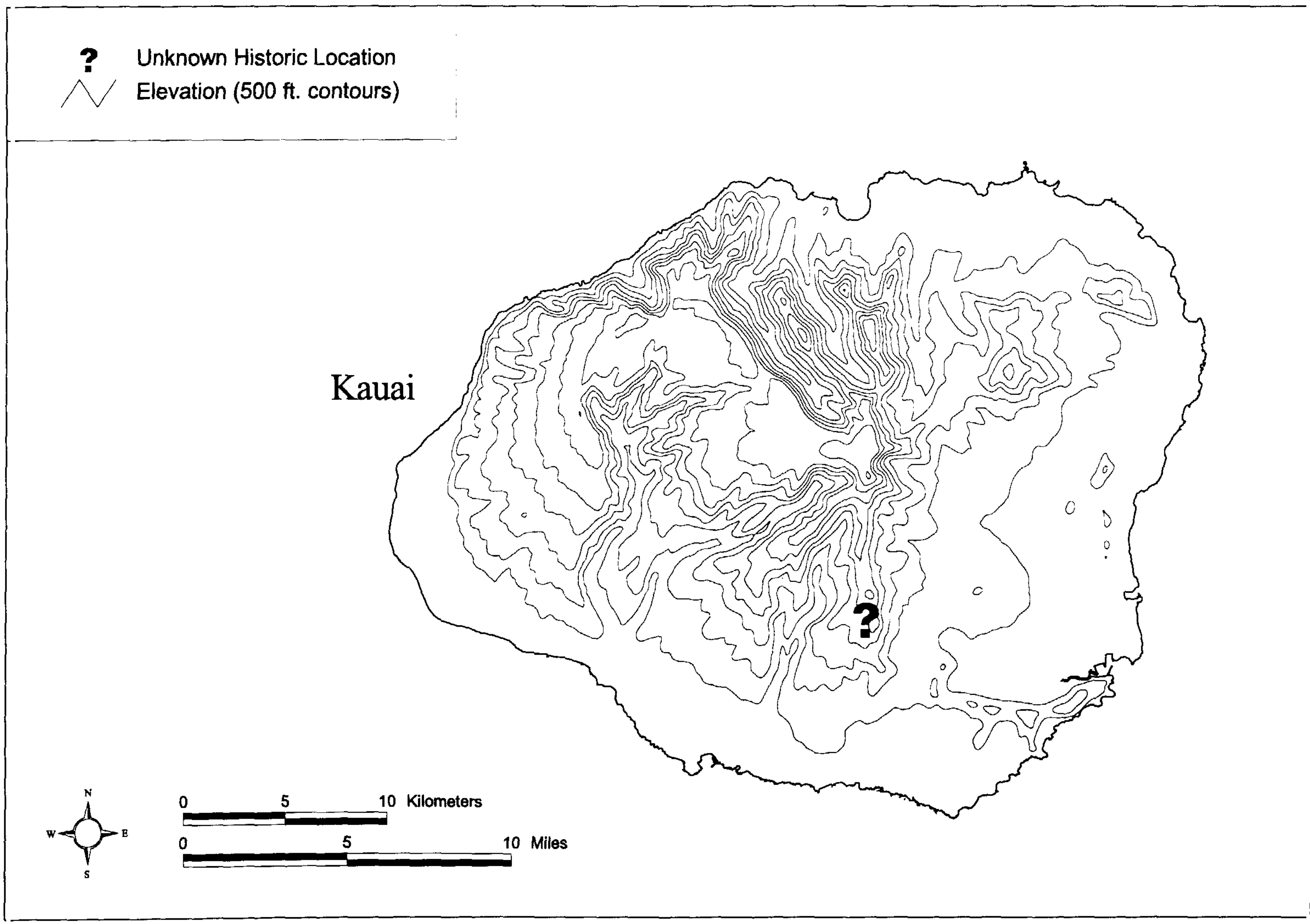


Distribution of *Phlegmariurus nutans* (1 of 2)



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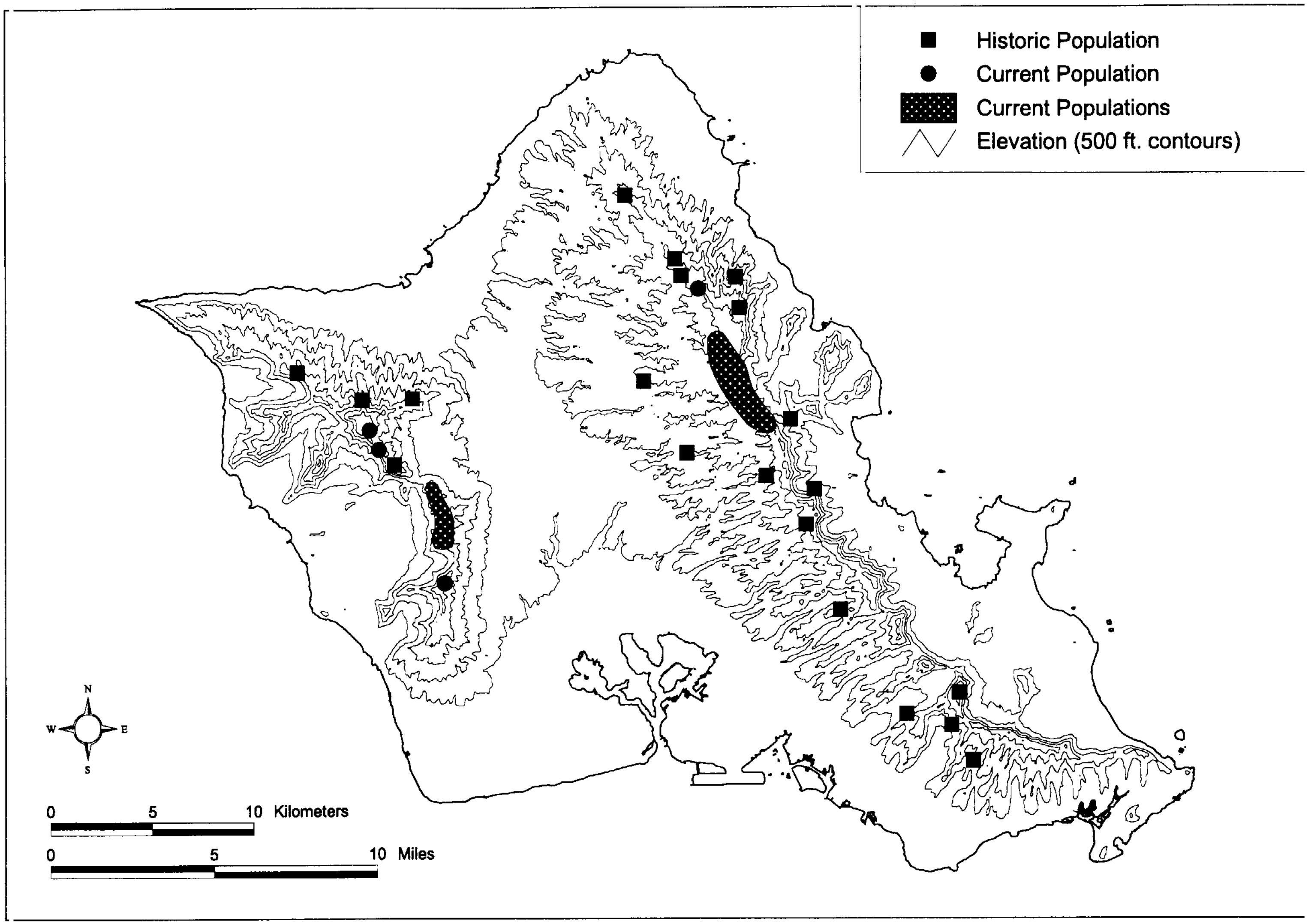

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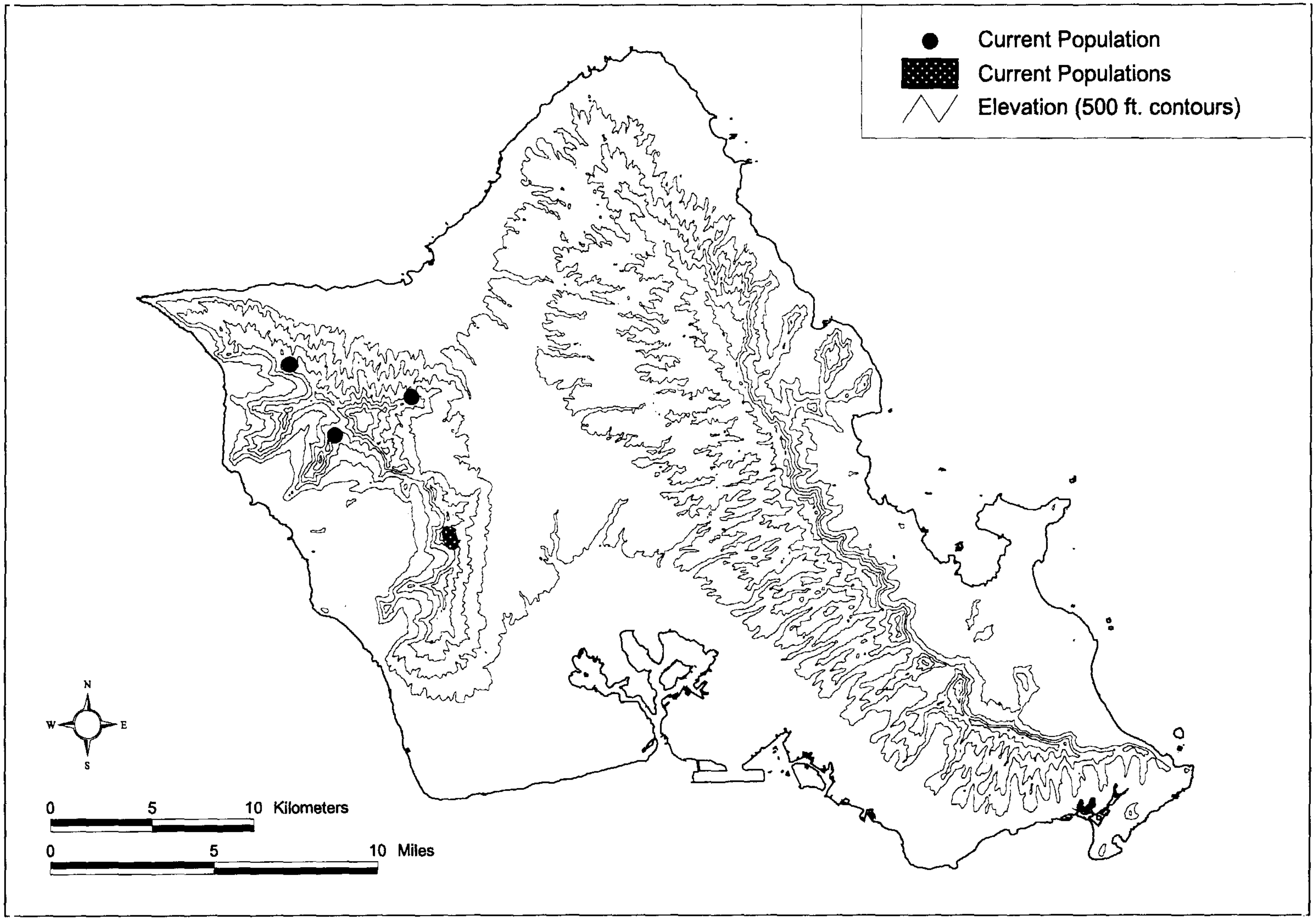

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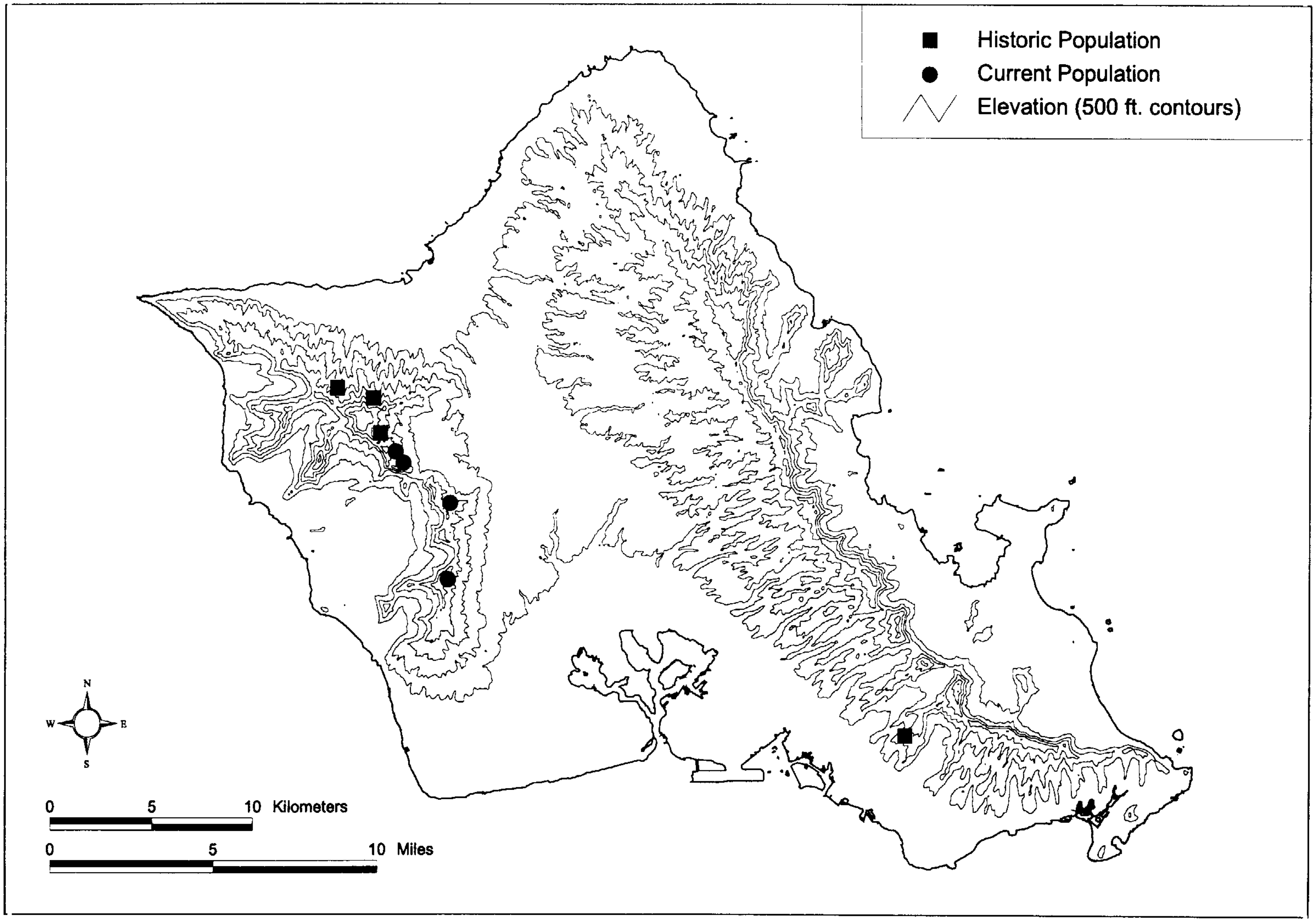

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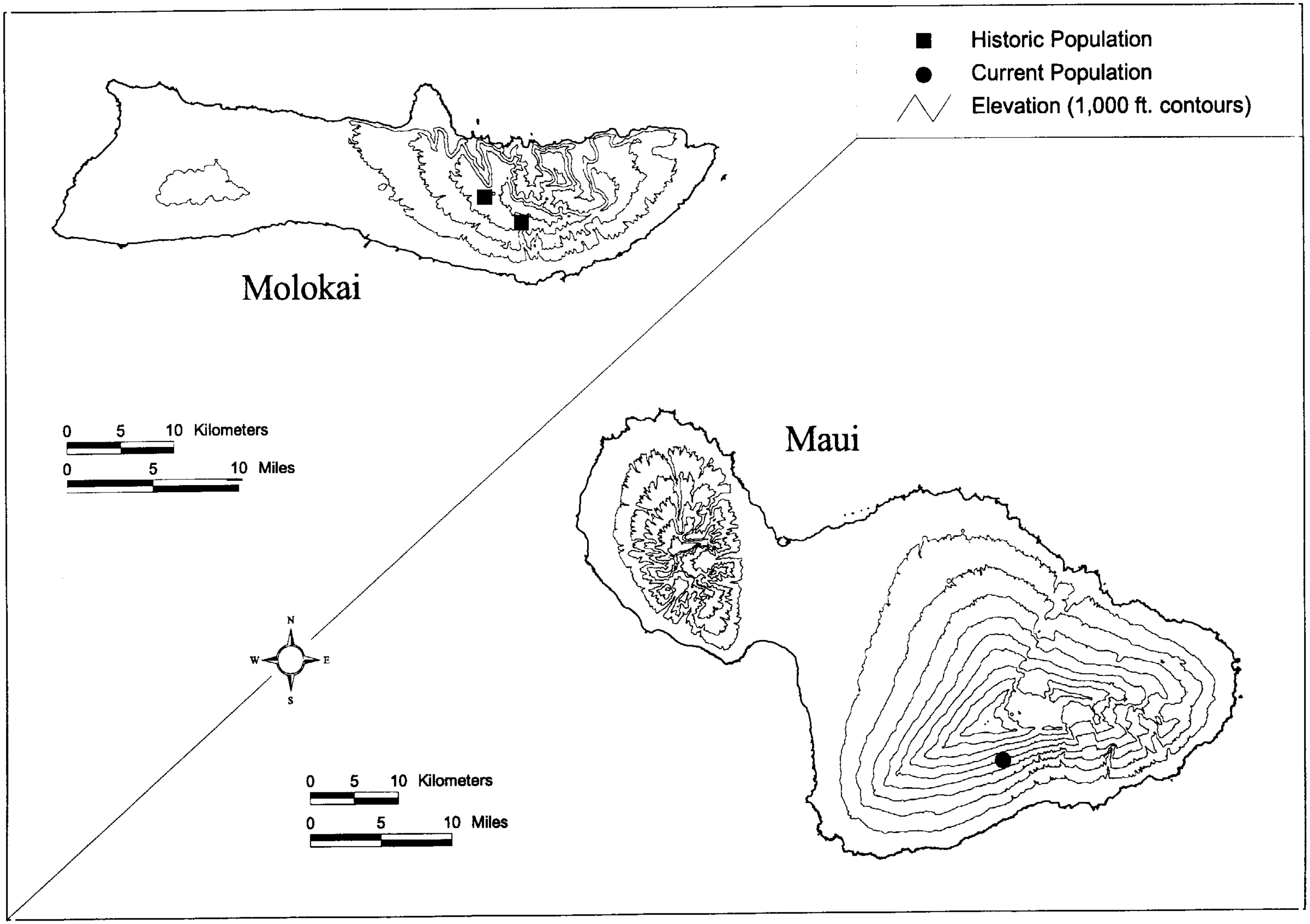

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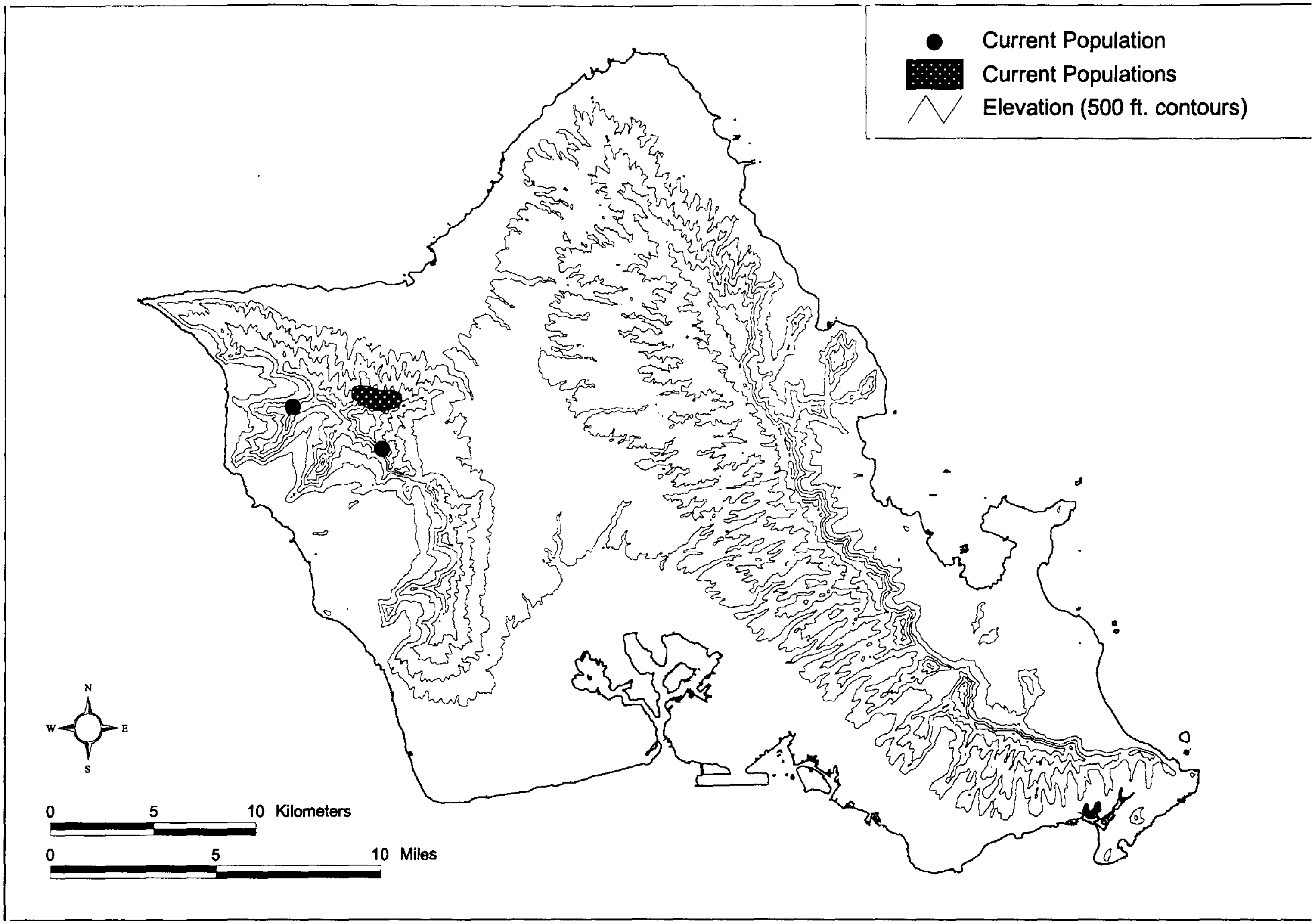

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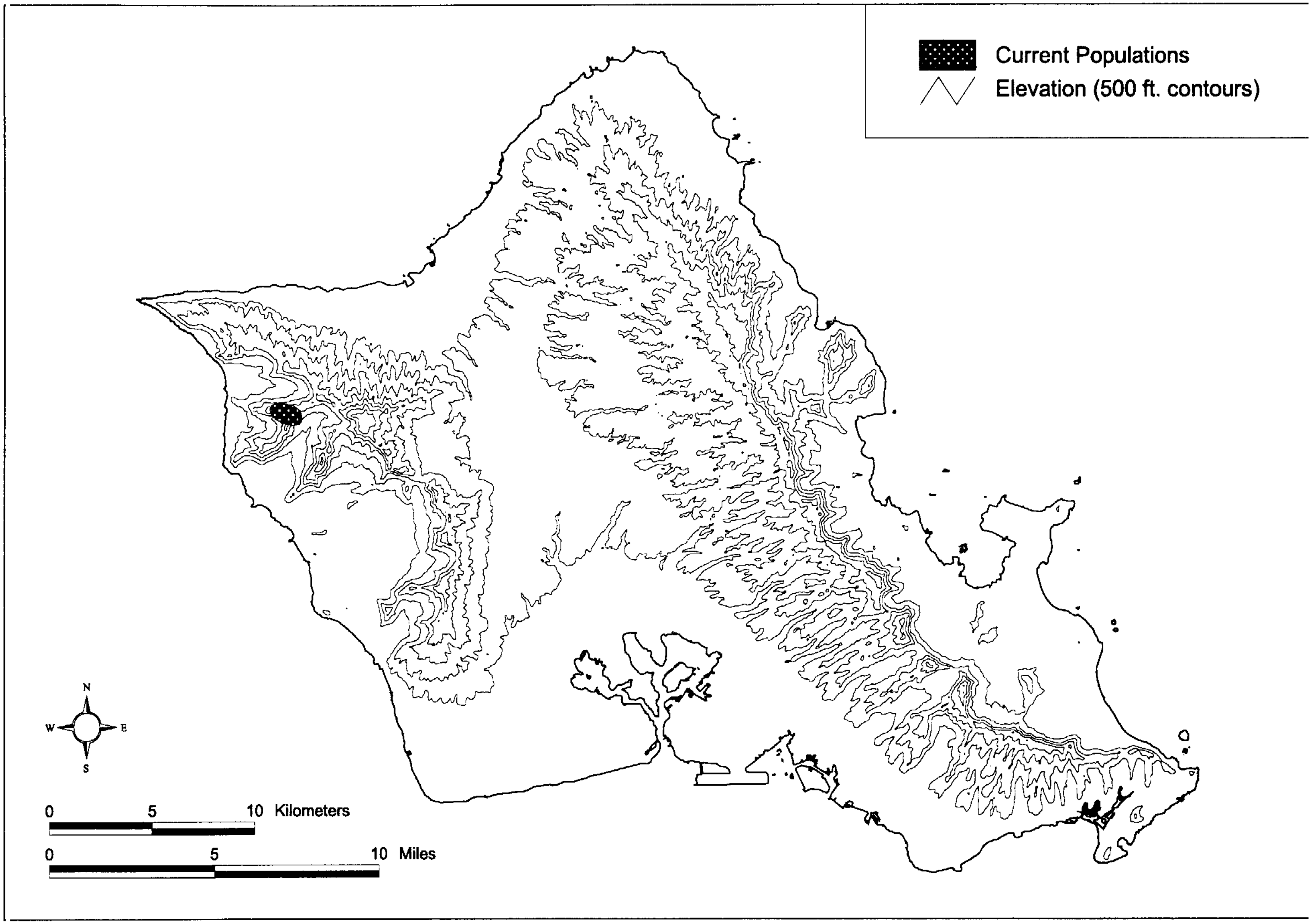
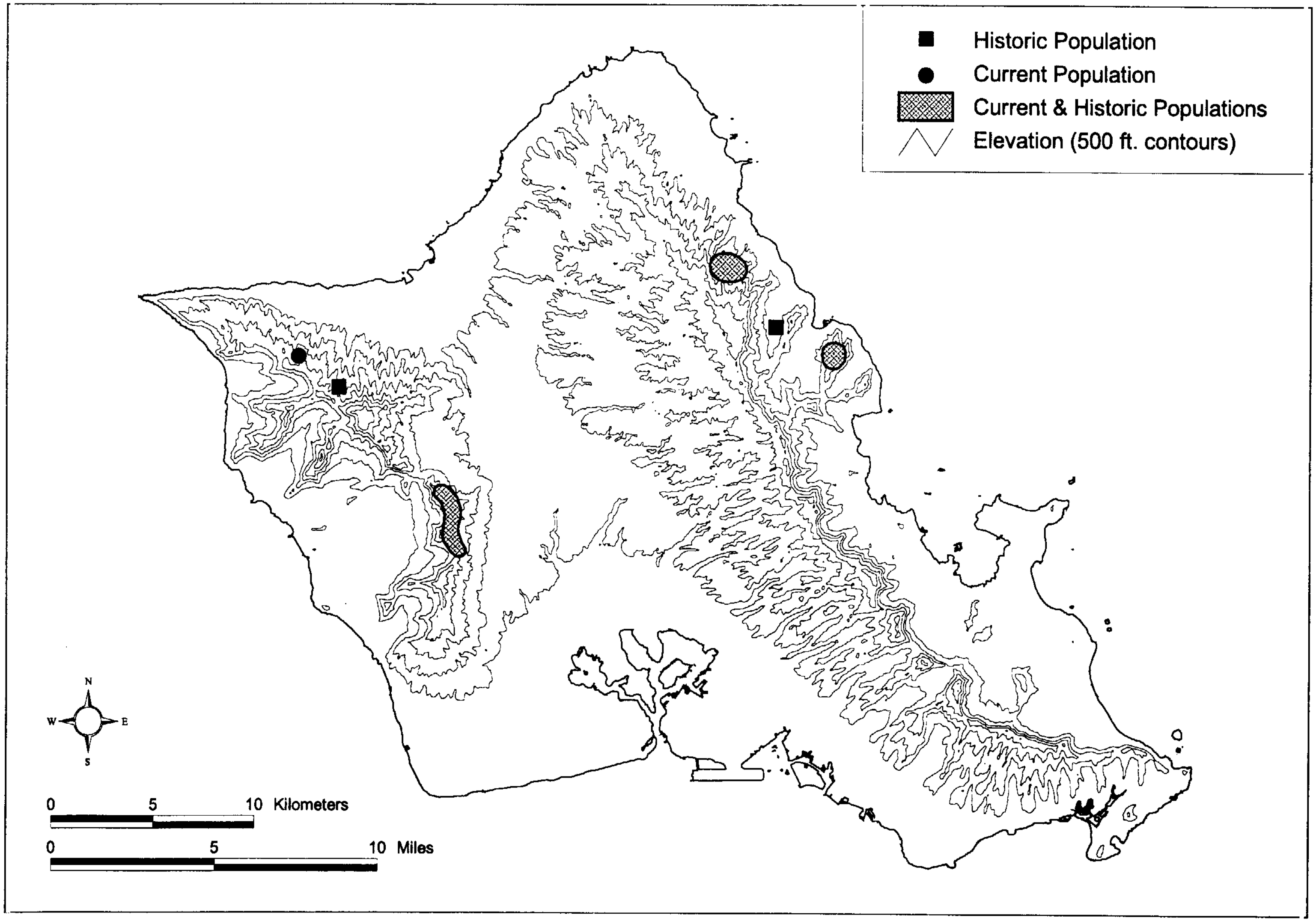
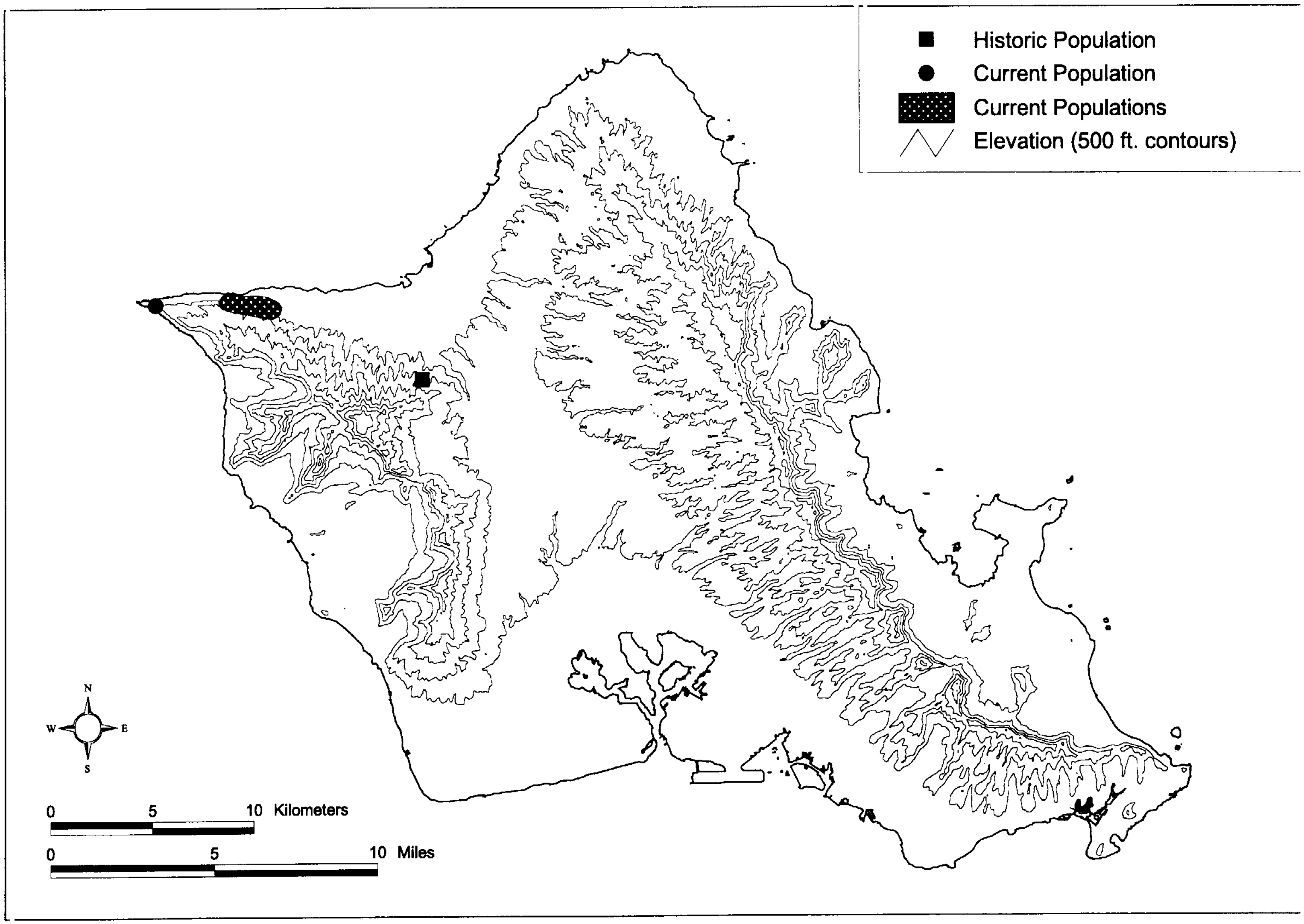


Distribution of *Sanicula mariversa*



Distribution of *Schiedea kaalae*



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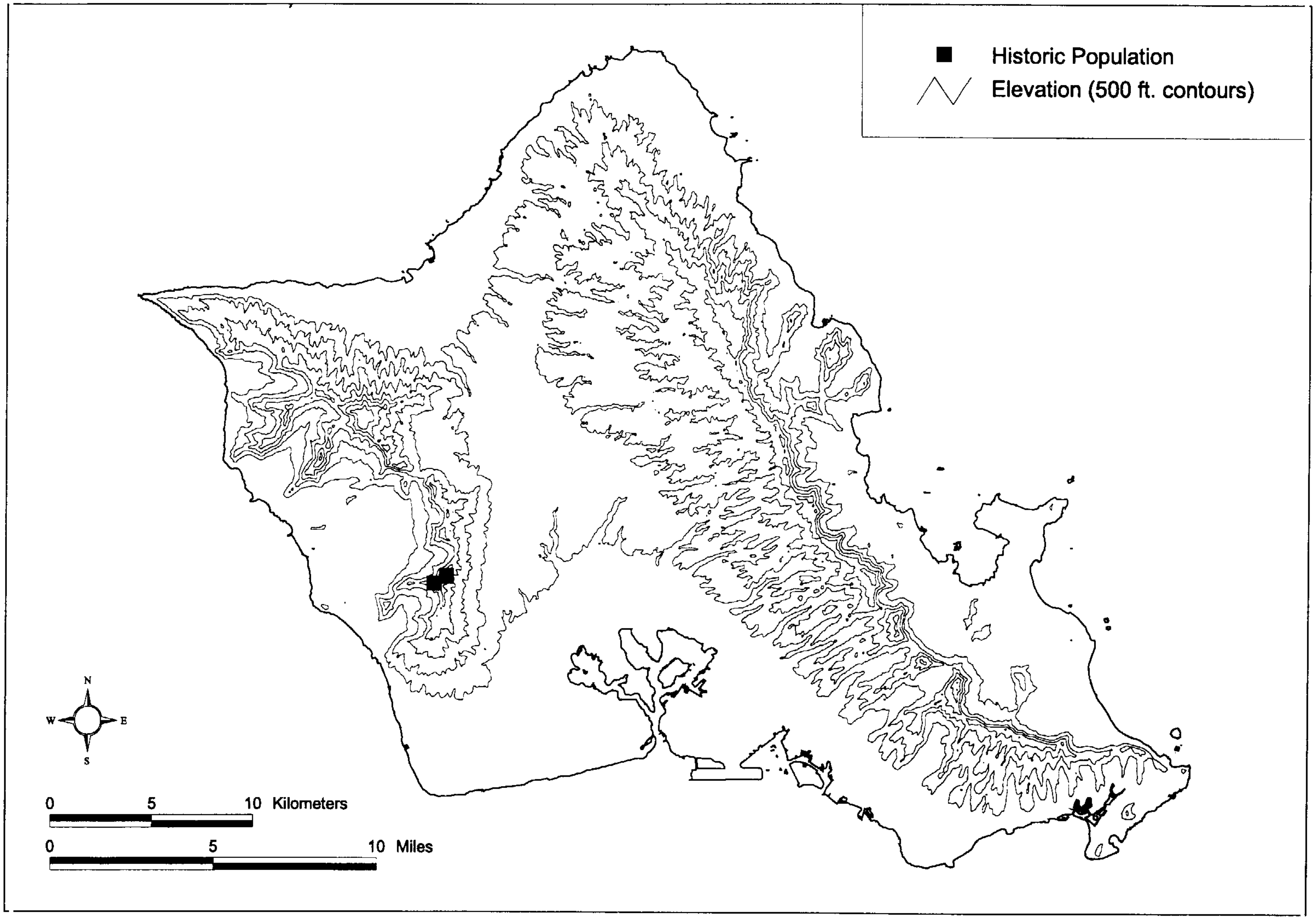

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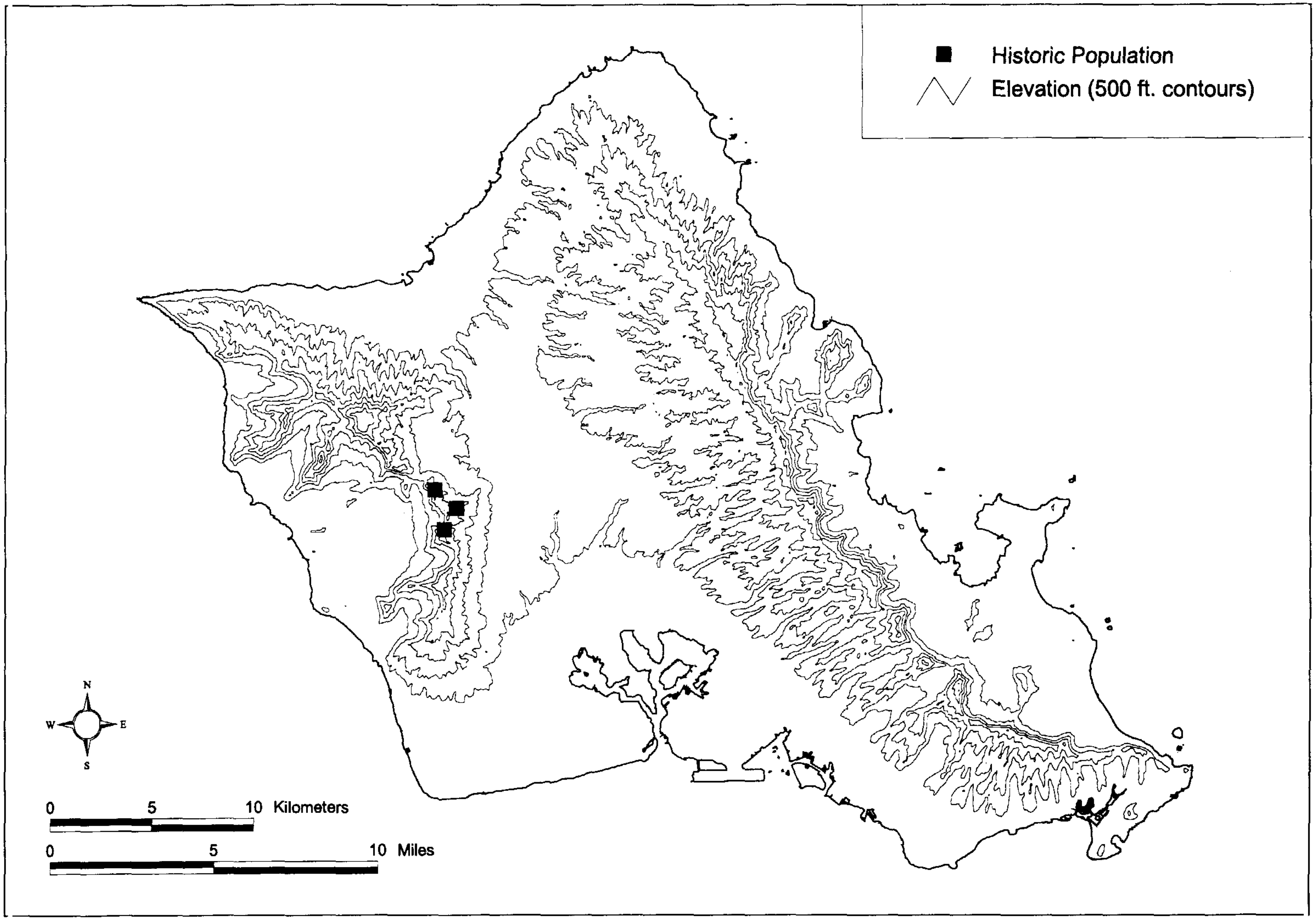
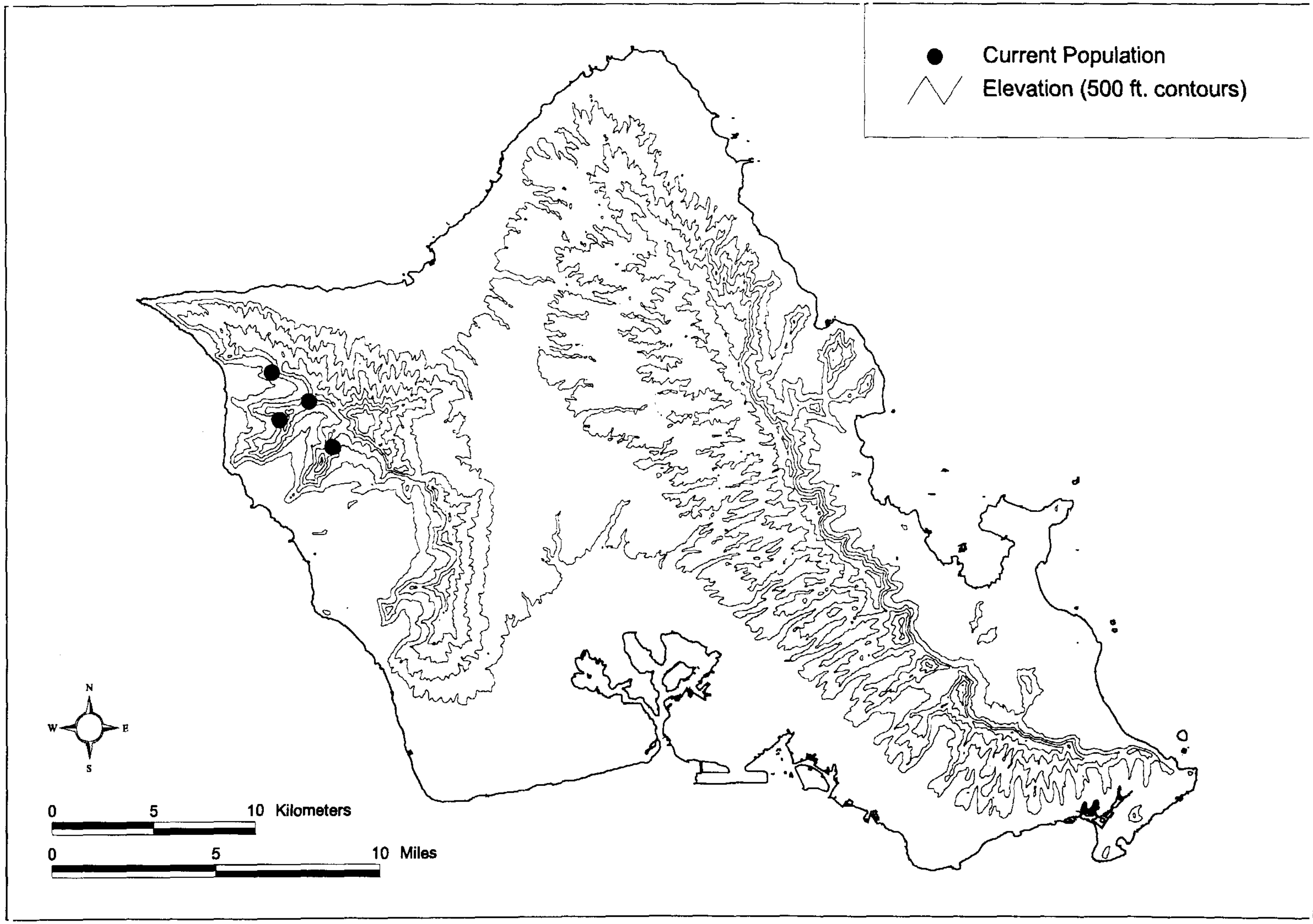
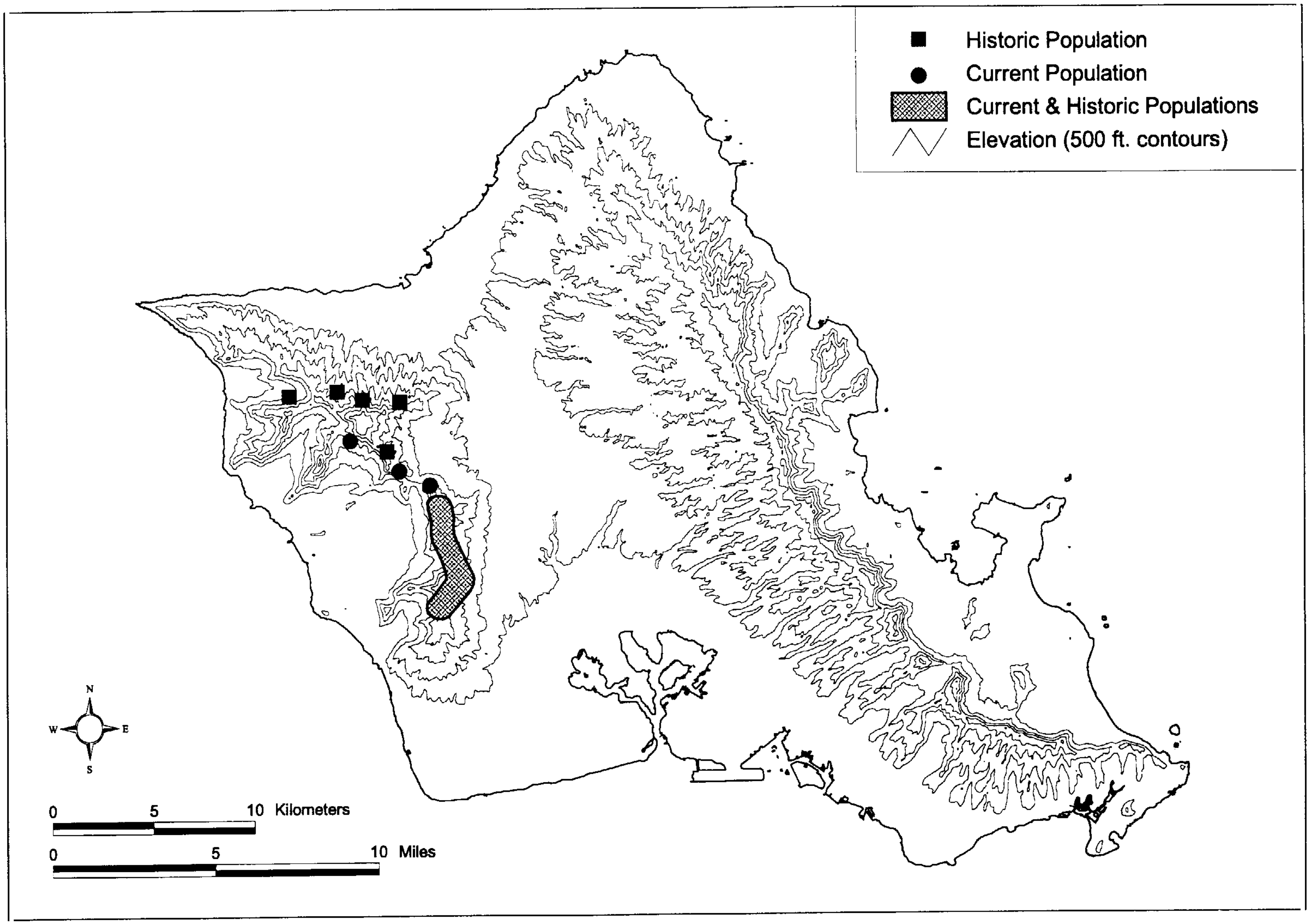


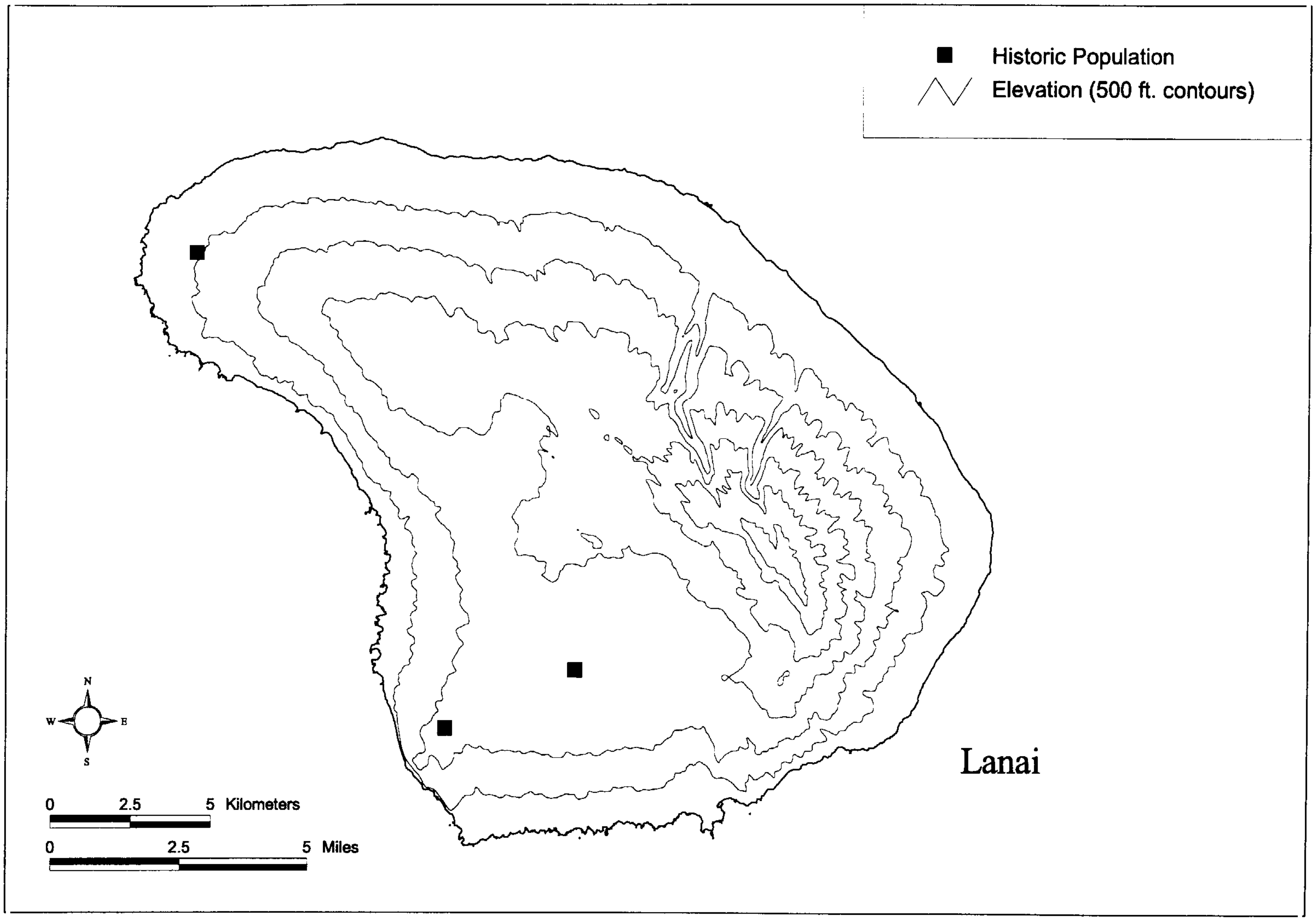
Distribution of *Stenogyne kanehoana*



Distribution of *Tetramolopium filiforme*



Distribution of *Tetramolopium lepidotum* ssp. *lepidotum* (1 of 2)



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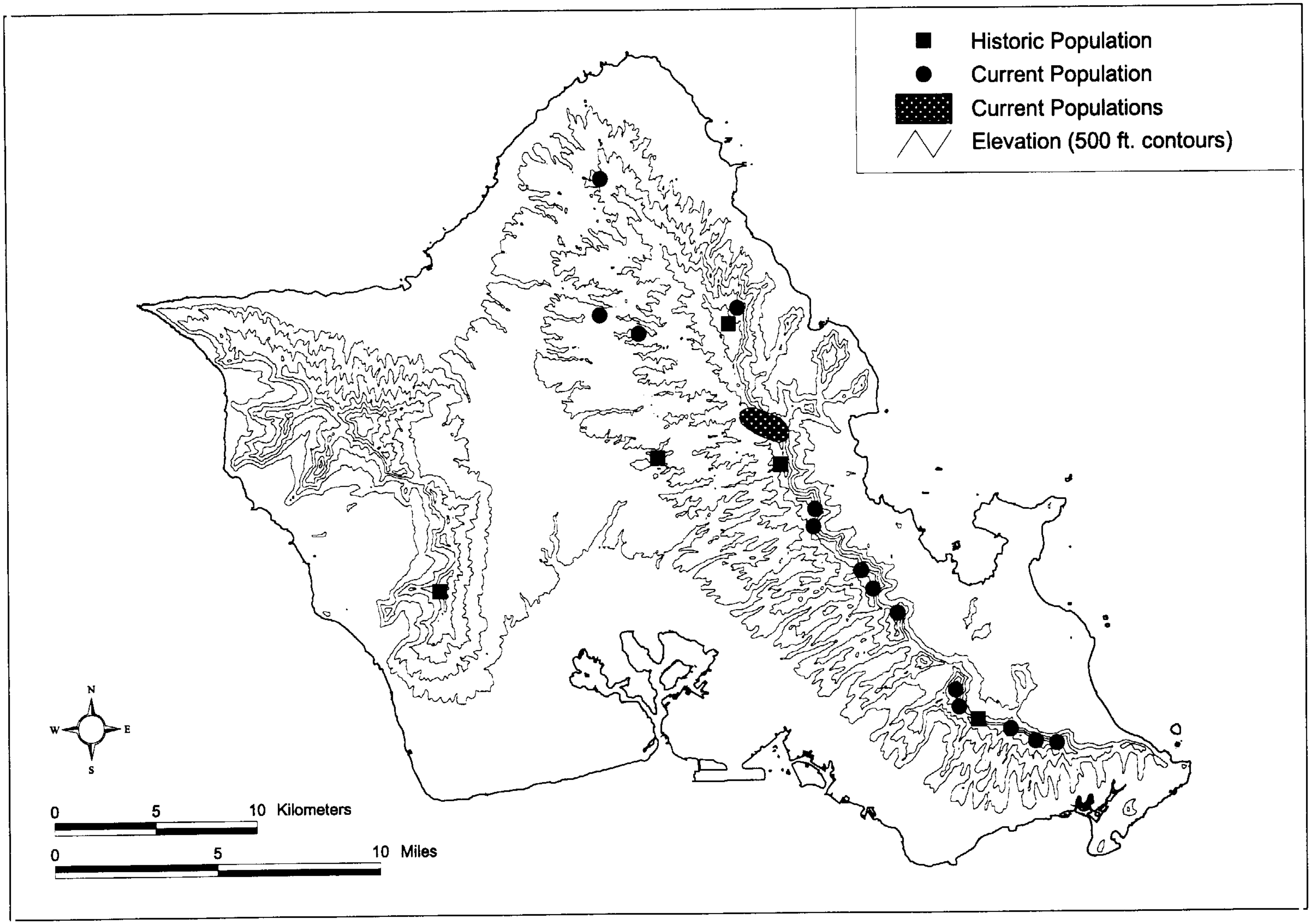

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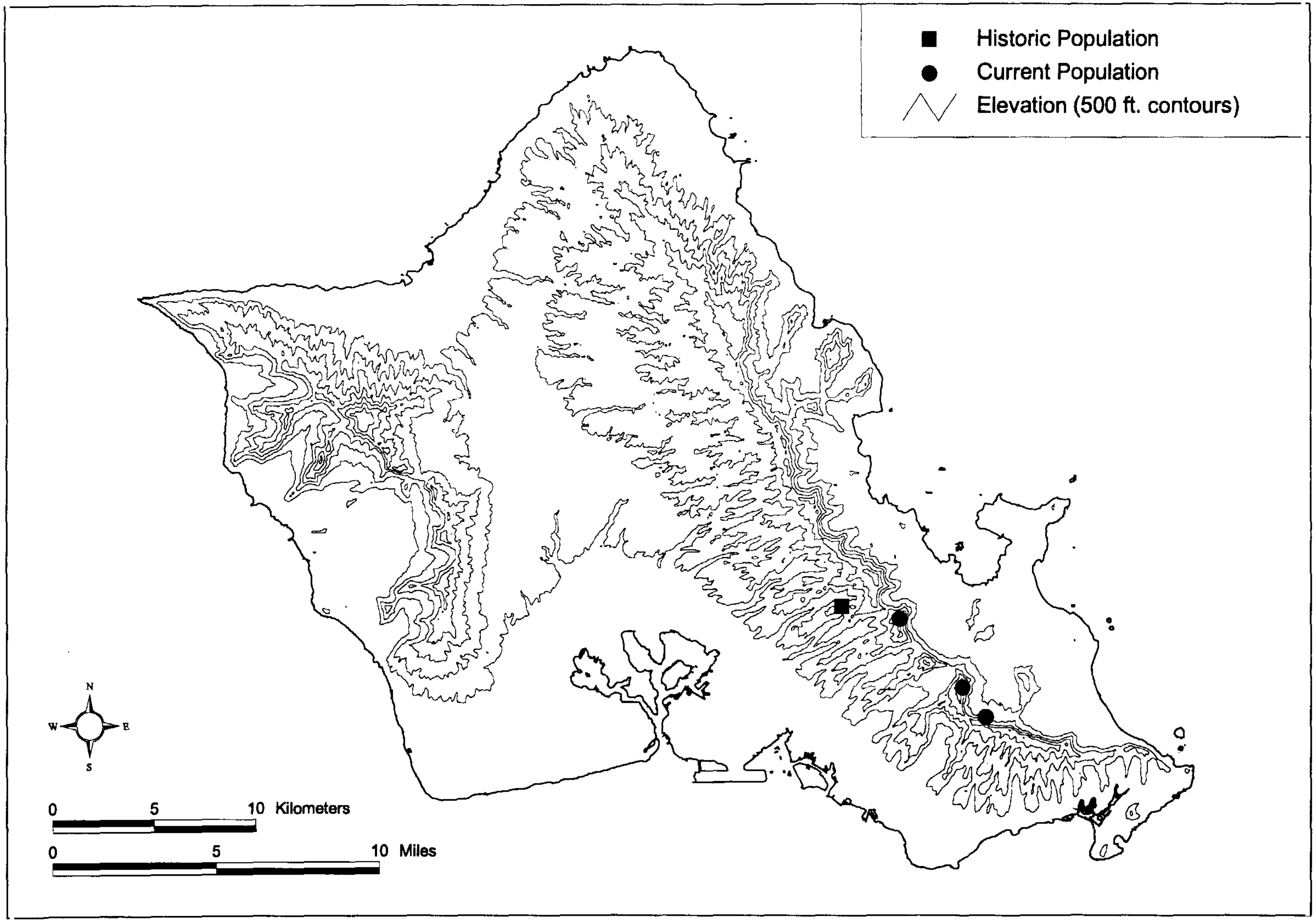
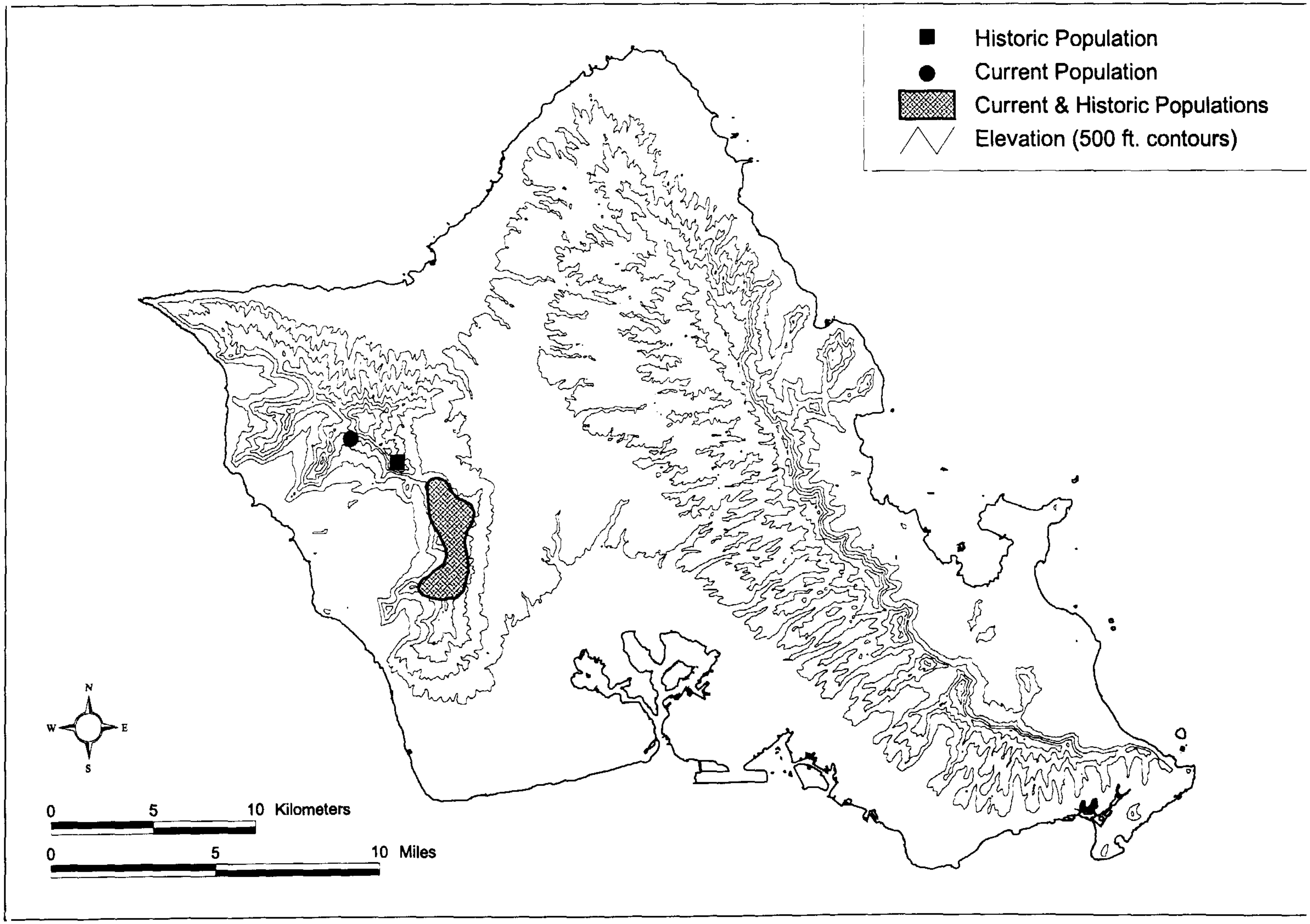
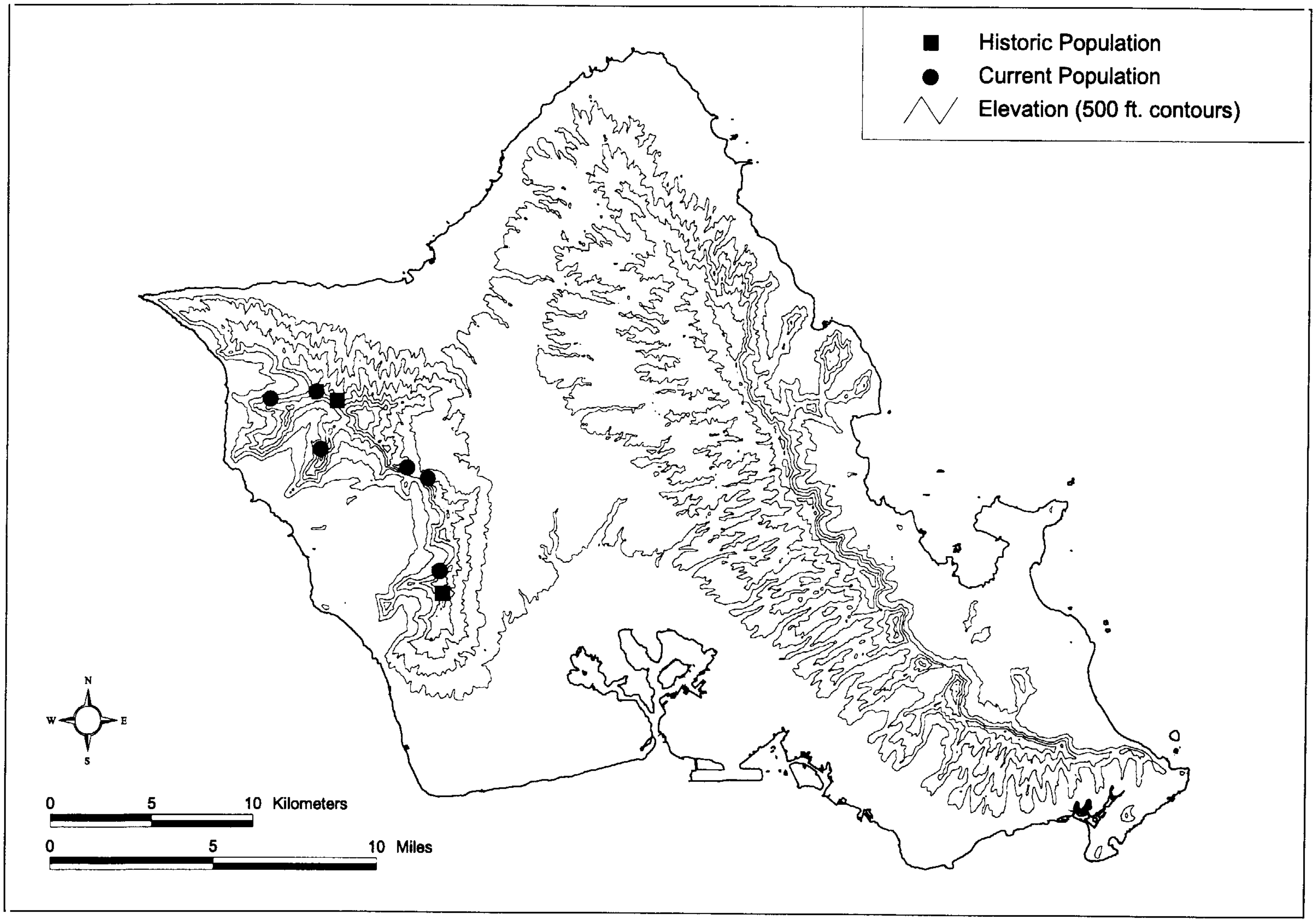


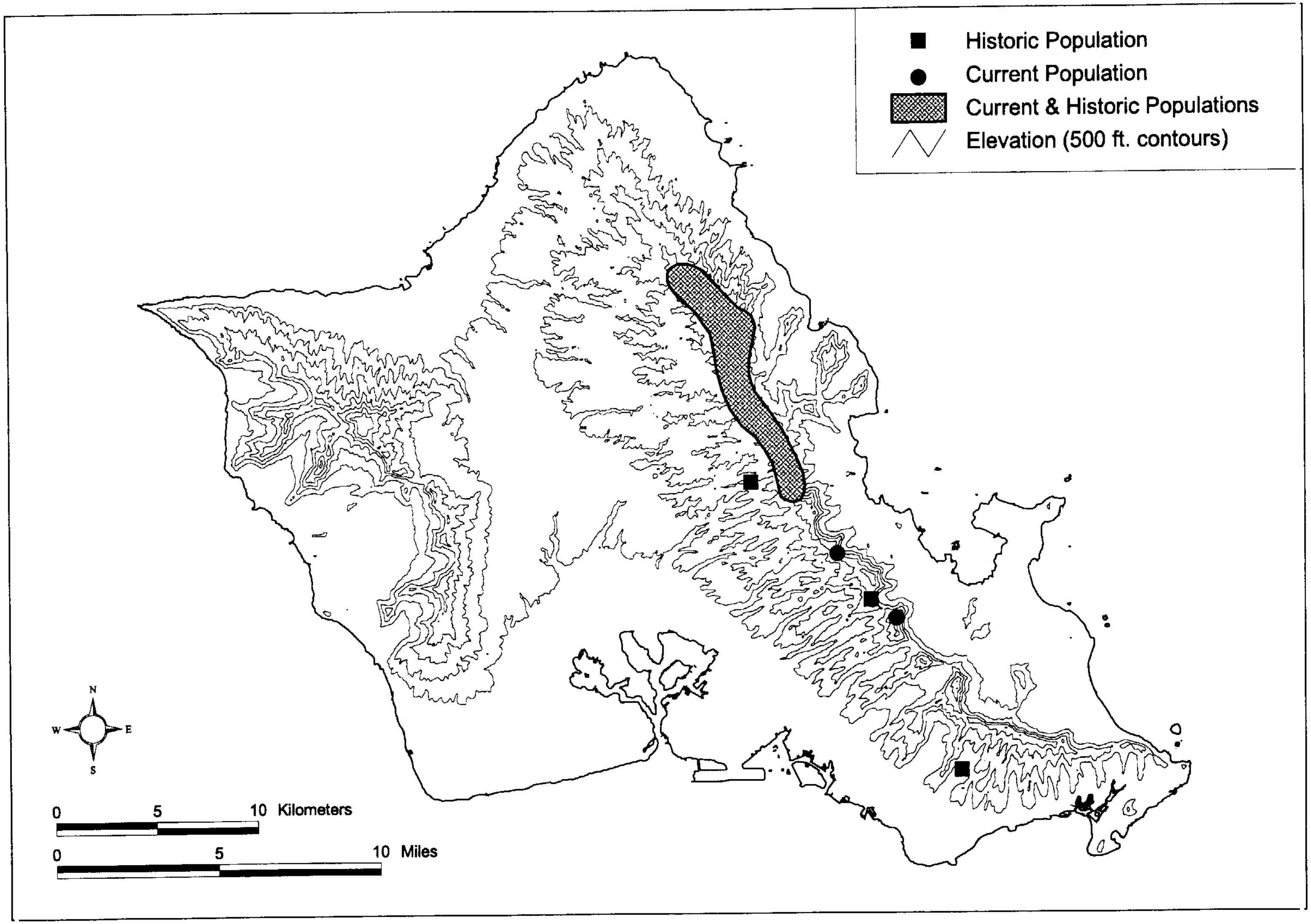
Distribution of *Trematolobelia singularis*



Distribution of *Urera kaalae*



Distribution of *Viola chamissoniana* ssp. *chamissoniana*



Distribution of *Viola oahuensis*

APPENDIX D

The Recovery Priority System uses the criteria of (1) degree of threat, (2) recovery potential and (3) taxonomy (level of genetic distinctiveness). By applying these criteria, all listed species are assigned a species priority number of 1 through 18. A fourth factor, conflict, is a supplementary element in determining what actions are to be implemented for recovery of a species. In addition, the fourth factor gives priority, within each category, in preparation of recovery plans to those species that are, or may be in conflict with construction or development projects. Thus, the species retains its numerical rank and acquires the letter designation of "C", indicating conflict (1C-18C).

A detailed discussion of the Recovery Priority System can be found in Federal Register Vol. 48, No. 221, Pg. 51985 of the issue dated Tuesday, November 15, 1983.

Recovery Priority Table

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic genus	1	1C 1
	High	Species	2	2C 2
	High	Subspecies	3	3C 3
	Low	Monotypic genus	4	4C 4
	Low	Species	5	5C 5
	Low	Subspecies	6	6C 6
Moderate	High	Monotypic genus	7	7C 7
	High	Species	8	8C 8
	High	Subspecies	9	9C 9
	Low	Monotypic genus	10	10C 10
	Low	Species	11	11C 11
	Low	Subspecies	12	12C 12

Low	High	Monotypic genus	13	13C 13
	High	Species	14	14C 14
	High	Subspecies	15	15C 15
	Low	Monotypic genus	16	16C 16
	Low	Species	17	17C 17
	Low	Subspecies	18	18C 18

APPENDIX E

SUMMARY OF COMMENTS

The U.S. Fish and Wildlife Service received comments on the Draft Recovery Plan for Oahu Plants from the Center for Plant Conservation, the City and County of Honolulu Fire Department, the Division of Forestry and Wildlife, the Hawaii Department of Agriculture, the Hawaii Department of Transportation, the Hawaii Land Use Commission, the Office of Hawaiian Affairs, the U.S. Army Resources Management Program, and The Nature Conservancy of Hawaii. Most of these comments provided additional information on numbers of population/individuals, distribution of certain taxa, and editorial changes. These comments have been incorporated into the final plan. Additional comments are addressed specifically below.

Comment 1: Many of the most significant alien weeds are widespread over large areas of habitat formerly occupied by many of Oahu's endangered species. We suggest that biocontrol be seriously considered as the long term solution to control several of the weeds that are significant threats to endangered species.

Service Response: The Service agrees that due to the widespread nature of many weeds and the time, cost, and logistics of weed control, use of biocontrol agents to control alien plants should be considered. The Service supports the use of biocontrol provided adequate testing is conducted for host specificity using native plants. This is necessary to ensure that native plants, including endangered species, are not adversely impacted by the release of biocontrol agents. We have included a synopsis of biocontrol efforts to date for each alien species in the section entitled "Overall Reasons for Decline and Current Threats, Alien Plants". Biological control is also considered in the Stepdown Outline and Narrative.

Comment 2: It would be helpful to summarize this extensive plan by including a map that indexes the number of species, which species, and their numbers for each geographical area. This would help in prioritizing areas for fencing, weeding, and rat control. Areas with critical "basket" cases could be highlighted. This map would be helpful for planning and reference for any trips, such as collection of *ex situ* materials, census, weed and rat control, and fence maintenance.

Service Response: For such maps to be useful for planning management trips, detailed locations would need to be provided. The Service does not provide detailed locations for endangered plants in recovery plans in the interest of protection from vandalism. Furthermore, such a map would be too complex to print in the black and white format to which we are restricted. The Recovery Plan is intended to be a guide for management. We believe that each agency is best equipped to create the supporting materials for their individualized management programs.

Comment 3: Species descriptions, provided in previous recovery plans, are missing for all 66 species.

Service Response: As stated in the introductory paragraph of the Species Accounts, descriptions of the taxa and taxonomic explanations may be found in the final rules listing these plants, published in the *Federal Register*. For more complete descriptions, we recommend consulting "The Manual of Flowering Plants of Hawaii" by Wagner, Herbst, and Sohmer (1990).

Comment 4: A summary table would be helpful in prioritizing weed control programs.

Service Response: The most significant weeds to these 66 endangered species are summarized in the section entitled Overall Reasons for Decline and Current Threats.

Comment 5: No consideration is given to topography and if fencing can be built without jeopardizing the habitat, the species to be protected, or human lives trying to install fence. The localities need to be considered when recommending how to alleviate the threat.

Service Response: Fenced enclosures are only recommended where feasible. In situations where a plant may occur in an area difficult to enclose such as a cliff, strategic barrier fencing is recommend, and other means of ungulate control, including aerial shooting of goats and snaring for pigs is recommended and supported by the Service.

Comment 6: When little or nothing is known about a species, how does one manage the species effectively? There is a real need to get research going on the life history, threats, and lack of reproduction. Only 8 of the 66 species are shown needing any research. Many more threats will become obvious that are now being overlooked once we know more about the species. This will change the emphasis, costs, and approaches in recovering species.

Service Response: Recommendations for research are included in the Stepdown outline and Narrative (Tasks 3 and 31-38, respectively).

Comment 7: The total costs for the Oahu recovery plan are not consistent with the costs for other recovery plans. Please explain how these figures were determined.

Service Response: Costs given in the Implementation Schedules are rough estimates. In many cases, costs are related to accessibility of the plants or suitable habitat for outplanting. Cost estimates are given for each species independently. It may be possible to combine tasks for a number of species that occur in the same area, minimizing overall costs. Additionally, the same research is needed for endangered and threatened Hawaiian plants covered by other Recovery plans. This research may be carried out simultaneously for a number of these plants.

Comment 8: We suggest that a set of priorities be established for management. We suggest that species with fewer than 50 mature individuals should have highest priority in the recovery plan.

Service Response: The plan has two sets of priorities. Each species receives a recovery priority number following its name in the Species Accounts. The recovery priority system is explained in appendix D. Population size is accounted for under both degree of threat, and recovery potential. Priorities are not based the number of individuals alone, because there are other factors to consider including the number of populations, original abundance, number and degree of threats, ability to be managed, and potential development. Each recovery action is further prioritized in the Recovery Plan Implementation Schedule for the Oahu Plants.

Comment 9: The importance of *ex-situ* propagation and outplanting should be emphasized in each species account.

Service Response: *Ex-situ* propagation is recommended for each species in the Stepdown Outline and Narrative. In the interest of preserving space, *ex-situ* propagation is only mentioned in the species accounts section for those species that are not currently represented in arboreta collections.

Comment 10: In the budget table, the responsibilities of each agency are not backed by official agreement. Agencies will not assume responsibility for implementing the actions without extensive discussion and justification of the biological approach and cost. Perhaps the recovery plan system would have more clout and follow-through if memorandums of agreement were signed between the agencies involved and the U.S. Fish and Wildlife Service

Service Response: We view the recovery plans as guidelines for management. We also recognize that each agency has its own program needs and unique financial situations. We hope that the recovery plan can serve as a catalyst for interagency discussion and planning for recovery. The Service would like to work cooperatively with other public and private agencies and organizations, and has several mechanisms for doing so. We invite discussion and hope to collaborate on recovering these species.

Comment 11: What is a population as defined by the recovery plan, and how is it useful?

Service Response: A population is defined by Wagner *et. al.* as a "group of potentially interbreeding individuals growing together at any particular time. In clonal or self pollinating species the term applies to a local community of physiologically or morphologically similar individuals." To arrive at a scientifically accurate determination of population, the reproductive biology of the species needs to be fully understood and research confirming interbreeding must be conducted. For Hawaiian plants, where pollination strategies are largely unknown and pollinators are potentially extinct, this essential knowledge is largely missing. In our experience, local botanists disagreed or did not know which individuals comprise a reproductively viable population. Therefore, our determinations of populations in the recovery plan reflect the recovery team's educated guesses based primarily on separate element occurrence records from the Hawaii Natural Heritage Database.

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Augustl 1998